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A Weekly Journal of the Mining and Mineral Industries

April 10, 1920

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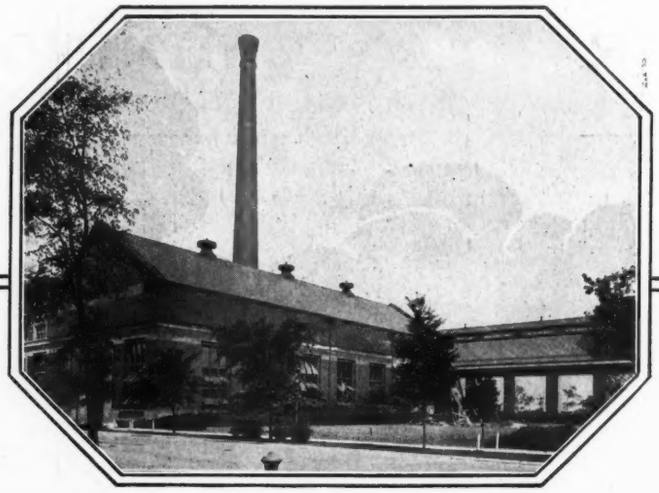
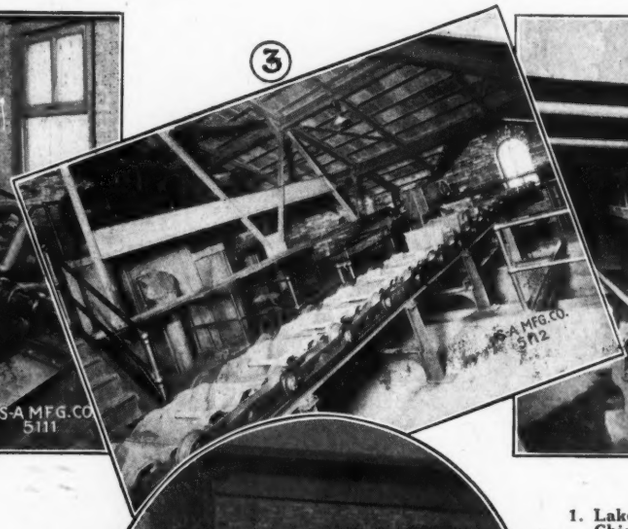
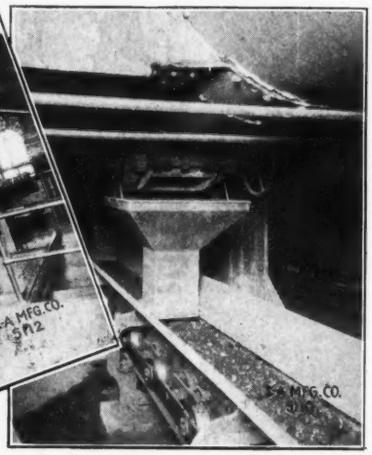
This issue differs from previous special issues of Engineering and Mining Journal devoted to this subject in that the 32-page supplement on milling subjects is furnished in addition to the regular weekly magazine.

In the whole mineral industry probably no single field offers more opportunity for progress nor more varied problems of practical interest than does the crushing, grinding, and concentration of ores.

Annual Milling Number







Exterior and interior views of the Lake View Pumping Station, Chicago, equipped with S-A Coal and Ash Handling Machinery.

1. Lake View Pumping Station, Chicago.
2. Upper Bend Idler of Storage Conveyor.
3. Storage Conveyor with Overturning Buckets discharging to Boiler House Conveyor.
4. Lower Run of Storage Conveyor with Loading Spouts attached to Bunker Gates.
5. General View of Disappearing Tripper in Idle Position.

S-A Coal and Ash Handling Machinery at the Lake View Pumping Station

STEPHENS-ADAMSON MFG. CO.

Aurora, Illinois

Engineering and Mining Journal

Annual Milling Supplement

Edward H. Robie, Metallurgical Editor

April 10, 1920

Leaders in Metallurgical Practice
John Van Nostrand Dorr

TO ONE who has listened to the crunch of the gyratories and to the roar of the ball mills; who has watched the jerks of the tables and the foaming of the flotation cells, the thickener tanks in a mill seem serene and uninteresting. The duplex classifier is also a deliberate, easy-going machine. Neither is at all typical of the life of the man who invented them and applied his sagacity to their commercial development. J. V. N. Dorr had difficult problems to handle from the start, when he was working directly under Thomas A. Edison on the recovery of gold from South Carolina sulphide ores. The assumed facts were, first, the gold existed free in the pyrite; second, roasting was too expensive; and, third, unroasted pyrite prevented chlorination. The process evolved by "the old man" and tested by Mr. Dorr was as follows: First, grind to 60 mesh to liberate the gold particles. Second, treat with asphalt solution to coat all the particles of gold and pyrite. Third, heat sufficiently to drive one atom of sulphur from the pyrite, thus changing its asphalt wrapper to a sulpho-asphalt compound insoluble in chlorine. Fourth, dissolve the unchanged asphalt from the gold particles. Fifth, dissolve the gold particles in chlorine. Somehow it never worked. Nineteen years ago Mr. Dorr was working in the Black Hills of South Dakota, and, with another man, determined to take over the old Rossiter mill to treat ores from some abandoned mines at Terry. The mill was equipped with a No. 2 Gates crusher, a drier, seven bucket elevators, and five sets of rolls to crush fifty tons of ore to 30 mesh, and had been remodeled five times. The venture was a success, and an additional ore supply made a further remodeling necessary. A Blake was substituted for the small Gates, the worst roll was superseded by the only good one to be found, a concrete mixer was installed for moistening the ore with cyanide solution to hold down the dust, and a centrifugal pump driven by a threshing-machine engine was put in to elevate the tailings to a pipe carried on telegraph poles out to the flat.

JOHN V. N. DORR

A modern seventy-five-ton mill was then decided on, in which Mr. Dorr and two others put all their faith and funds, the latter including all they could borrow from friends, banks, and even from the Terry Miners' Union. The mill may have represented, as Mr. Dorr says, the overconfidence of inexperience, for it certainly departed from Black Hills practice. Wet-crushing direct cyaniding was then in its infancy. Slimes were a bugbear, cone separation was the fashion, and stamp mills were considered the only means for grinding. The new mill consisted of rolls, a Chilean mill, double cone classification, a leaching tank, a continuous cone slime collector 22 ft. in diameter, and the first Moore process to operate any length of time successfully. The mill started in January, 1904, and lost money steadily, owing to difficult classification, to sand which would not leach, and to slime for the Moore process, which was too full of sand. That spring Mr. Dorr got nine years of experience. Preliminary experiments had indicated the virtue of mechanical classification, when one Sunday afternoon the operators were working around the 22-ft. settling cone to stop the foam from overflowing. One of the boys walking on the rim threw it out of a delicate equilibrium caused by insufficient foundations, and down it dropped, spilling probably one-third of the tonnage of slime pulp and nearly washing that portion of the mill down the hill. Continuous operation was essential to stand off the creditors.

Of course there was nothing to do but to build the first Dorr classifier. Dimensions and slopes were guessed at, and when the machine started it would do good work for perhaps half an hour and then clog up and quit. Mr. Dorr spent sixty hours on the job, lying down for naps while alterations were being made; but afterward it ran continuously and turned a monthly deficit into a profit.

Mr. Dorr feels that he has had his share of good luck. Is not much of this so-called good luck due to the kindly spirit of co-operation which those who have been associated with him, knowing the man, have been impelled, unconsciously, to offer?

The Present Status of the Stamp Mill

Possibly Three-Quarters of the World's Gold Ore Is Crushed by This Medium—Ball Mills Are More Fashionable on Most Other Ores—South African Practice Has Been Successful

BY ALLAN J. CLARK
Metallurgical Engineer, Lead, S. D.
Written exclusively for *Engineering and Mining Journal*

THE trend of recent crushing installations is such that the younger metallurgists are in danger of forgetting that the stamp mill is by no means an obsolete machine, and it may be well, therefore, to consider its present field and future prospects, and also to define its limitations. Little has been heard of the stamp mill in recent years, save a constantly swelling chorus pronouncing its requiem. Constant reiteration has its psychological effect, and every one has probably given some degree of acceptance to the thought that its period of approved application has passed.

What are the facts? Some light may be found by turning to the current copies of the mining journals published in this country, and examining their advertising pages. A search of three issues has shown ten items offering ball mills, half as many offering ball-mill accessories, and not a single advertisement of the stamp mill. In the reading pages of one of these issues, however, was found Mr. Spurr's statistical article, "Who Owns the Earth?" (*Engineering and Mining Journal*, Feb. 7, 1920), in which it appears that 86 per cent of the world's gold comes from territory of the United States and the British Empire. Passing in mental review the great gold mines of the world, a hasty estimate would be that three-quarters of the ore from which this gold was won was reduced in stamp mills. Add to this the stamps crushing silver ore in Nevada and Mexico. Consider, now, the description of the New Modderfontein mill, on the Rand (*Engineering and Mining Journal*, Jan. 24, 1920), with its statement that eight Nissen stamps are driven from a 40-hp. motor and crush thirty tons per stamp per day through a nine-mesh screen (which is presumably, in American idiom, a screen of three meshes to the linear inch).

It begins to be apparent that the stamp mill needs, not the undertaker, but the press agent. In making this statement I have no intent to disparage the ball mill, which I conceive to be a machine of many good qualities, as, for instance, its amazing compactness and its high capacity on suitable and suitably prepared ores. Neither shall I undertake any comparison of the two machines, as controversial discussion is in no sense worth while.

The gold metallurgist may be charged with having a predilection in favor of the stamp mill. He should be able to refute this by suggesting that the tube mill, forerunner of the ball mill, was lifted by him from the cement industry, and that the first ball mills were used in the West Australian gold mills in the first years of the present century. That they failed of acceptance elsewhere at that time need not be considered remarkable, as the ball mill of today owes its success to the contemporaneous development of classifiers of the Dorr type.

Fashions in metallurgy run to extremes, as fashions have a habit of doing. But in metallurgy, perhaps more than in the lighter concerns of life, there may be sound reasons for its trend. It may be of interest to examine the causes which determined the former popularity of the stamp mill and which now account for its lack of favor and for the vogue of the ball mill.

HOW THE STAMP MILL DEVELOPED

Considering the remote past, we find two general types of crushing machinery to have existed even in times of most primitive culture. From the pestle and mortar type, passing through spring-pole lifting devices, the early form of gravity stamp appears, which, as early as the time of Agricola, had been grouped in several units in a common mortar box and had developed a crude form of screened discharge, ridiculously inadequate to modern eyes, yet doubtless efficient enough for its time. Similarly, from the primitive grain-grinding devices of stone rubbing on stone, the evolution of the arrastre and Chilean mill can be traced. Rolls, ball mills, and the various types of coarse crushers are of a much later time in mechanical history, as they were more dependent on advances in iron and steel metallurgy and on efficient power transmission.

In the early days, gold was the most sought of the metals. Amalgamation was the standard metallurgical method for its recovery; indeed, if the crude concentration in riffle boxes and similar devices be excepted, it was the only method. It was altogether natural that the machine and the process develop together, and it is a striking coincidence that even today the stamp mill is unexcelled as an amalgamating device.

In practicing amalgamation, the quicksilver was fed into the mortar box, where, broken into minute globules by the constant beating and churning of the falling stamps, it was intimately mixed with the falling pulp. The various adjustments of the mill, the regulation of screen opening, of depth of discharge, and the design of the mortar, determined the daily output of the battery, or, to express it differently, they provided means for attaining the optimum time factor for the amalgamation of an individual ore.

This contact time is essential, if maximum recovery by amalgamation is the object sought. It is interesting to note that the finer particles of gold were the ones which required the careful mixing and beating with quicksilver. Given a properly established practice in a mill, it will be found that any change aiming to increase the output, and, in consequence, decreasing the time during which the individual particles remained in the battery, is attended by an increase in the gold present in the "slime" portion of the tailings.

At this period of metallurgical evolution, the gravity stamp was in the heyday of its popularity. Milling practice of this period is excellently described and discriminatingly discussed by T. A. Rickard in his "Stamp Milling of Gold Ores," one of the most entertaining

of the many delightfully readable books of this author. Its perusal suggests what I have often observed: that our predecessors may have suffered for lack of well-designed machinery; they may have failed to realize the value of written records and of consciously sought system; but they were close observers—almost uncannily close at times—and hard and persistent workers.

Was Well Adapted to Amalgamation

In those days the slime problem was not troubling the gold metallurgist—he had no cyanide plant to consider—and he was crushing to a reasonably fine pulp. Slime was objectionable to the concentrator man. He observed the large amount of gold in stamp tailings, and, to avoid it, turned rather toward the Chilean mill type of grinder, incidentally beginning to study the problem of re-grinding.

As has been shown, the stamp mill reached its pinnacle of success not solely because of its capacity as a crushing machine, but by its supreme suitability to the preparation of ore for subsequent metallurgical treatment. Following the course of its history indicates that its popularity has waned, not because of its failure as a crushing machine, as measured by its output for a unit of power, but because it has not so readily accommodated itself to the demands of changing metallurgical methods as have some other machines.

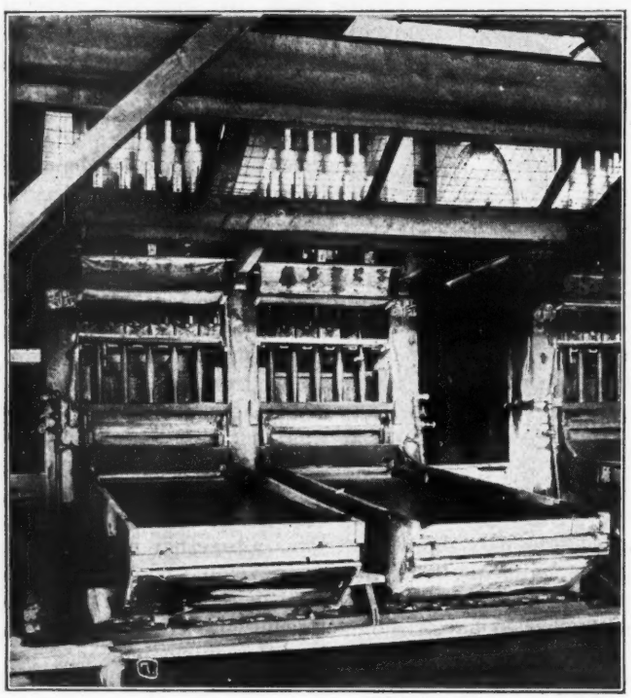


Photo by Art Lease, Lead, S.D.

A SECTION OF THE ARNICUS MILL, SHOWING MORTARS AND PLATES

To review rapidly these conditions, it may be noted that cyanidation at first supplemented and later even threatened to supplant amalgamation. Machinery was rapidly developed to meet the demands of the new process, each innovation calling for some readjustments in flow sheets, and often affecting the dominating position of the stamp mill. As the amalgamation of gold was a function of time, so its dissolution by cyanide solution was a function of time and of grain size. Given the means of reclaiming slime for treatment by cyanide, amalgamation of its gold became unnecessary. Slime treatment following fine-grinding—the "all-sliming" method of recent American metallurgy—found the stamp mill an unsatisfactory machine, in that the extreme dilution of battery pulp was a nuisance, whether water or cyanide solution chanced to be the liquid medium. The vogue of "all-sliming" has been a recent manifestation, but a wholesome realization is evident that this method may overreach itself and that a coarser product, with separate treatment for slime and sand, may give better economic results.

What, then, is the present field of the gravity stamp? Primarily, it must now make its appeal as a crushing machine. In recognition of this fact may be noted the tendency to increase the output of the stamp by increasing the falling weight and by delivering a coarser product to secondary grinding machinery. This line of advance was initiated and has been brought to its highest development in South Africa, where a well-established practice, a gigantic industry, and the rivalry engendered by professional competition of the technical staffs of the several operating groups have all helped to stimulate experimentation.

Having accepted the principle of stage reduction, the South African metallurgists followed it to its logical conclusion. Our own metallurgists accepted the principle and adopted heavy stamps, but in many instances partly nullified the advantages which should have been gained. This was due to the effort to crush in cyanide solution and to attempting a compromise between the demand of the stamp for a generous supply of water or solution and the equally insistent demand of the cyanide department that the circulating medium be kept at the lowest possible point. And, to digress, the fact is of interest that, just as the stamp mill found in amalgamation a process ready made to fit its limitations, so, in "all-sliming" and in crushing in cyanide solution the ball mill has found its perfect field.

Some of the Features of This Type of Crusher

The stamp mill has great flexibility. Falling weights may range from 900 to 2,000 lb.; and the discharge is positive in the sense that every particle must pass through the apertures of a screen selected for the particular work in hand. Depth of discharge, height of drop, volume of water, design of mortar, all permit of ready adjustment.

The capacity of the stamp mill is little affected by coarse feed. A 900-lb. stamp can deal successfully with pieces up to or even larger than 3-in. cubes, though there is reason to believe that, in an irregular feed, pieces of this size are responsible for some breakage. No material gain is accomplished by reducing the size of feed below 2-in. cubes.

The effective range of work as measured by the size of feed and of discharge is perhaps as great as or greater than that of any other machine. Not that it is advisable to attempt too great a reduction in a single stage, as may be evidenced by the data adduced by C. O. Schmitt ("Textbook of Rand Metallurgical Practice," Vol. II, p. 338), from which I abstract the following:

TABLE I. STAMP AND TUBE MILL DATA

Proportion of crushing allotted to stamps	80%	60%	50%	30%
Ditto allotted to tubes	20%	40%	50%	70%
Duty per stamp, tons	5.32	7.1	8.5	14.15
Cost of mill per ton per day	£41.41	£35.76	£32.94	£27.29

On the other hand, the stamp mill does not lend itself to the closed-circuit system now accepted as standard ball-mill practice. The distance between the points of

inlet and egress is too short, and the dilution of pulp too great, to make such an arrangement possible.

The stamp mill's advocates, indeed, take exception to one portion of ball-mill propaganda. They have noted the careful stage crushing by which the ore is prepared for the mill, and now they have been shown (Davis, *Bulletin A. I. M. E.*, February, 1919, p. 111) that, by adding to the duty of the mill's attendant classifiers, output is steadily increased. If one is at all architecturally minded, the "one easy step" seems strangely like a circular staircase.

The effect of the various adjustments of the stamp mill may be briefly summarized as follows:

Weight of Stamp—My observation has been that, when the weight of the stamp is the only variable, the duty is proportional to the falling weight. The screen analysis of the tailings is practically unaffected. That there is a limit to the weight which can be successfully used seems to be agreed. Bosqui (*Trans. A. I. M. E.*, Vol. 52, p. 33) thinks that the 1,550-lb. stamp is the conservative limit for five units in a single mortar box, and continues, in setting forth the theoretical advantages of the Nissen or single-unit stamp: "The serious defect of the conventional five-stamp arrangement is that it is impossible to adjust and distribute the feed properly. . . . All the stamps are not doing the same amount of useful work. The complex and mutually opposing currents set up within the mortar box make uniformity of feed impossible." All of which was very desirable when amalgamation was practiced, but has now become a problem to be mastered. Distribution of the feed water, so that a jet is delivered behind each stamp, helps to combat this difficulty. A shallow discharge is proper practice when output is the prime consideration.

Screen—By increasing the screen aperture, with other adjustments unchanged, an increased output is obtained. Practically all the increase will be found to be in the coarse sizes.

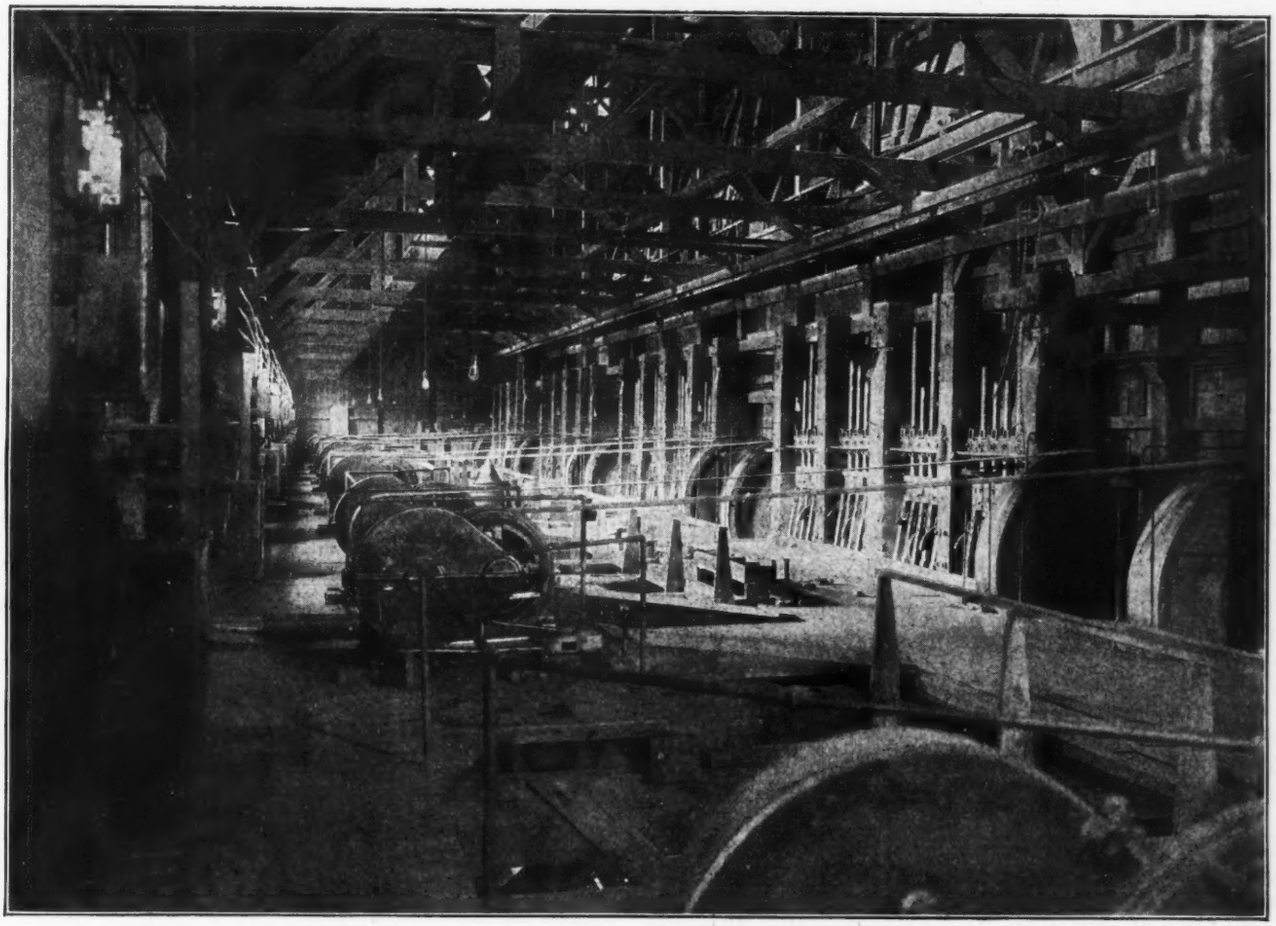


Photo by Art Lease, Lead, S. D.

CAM FLOOR OF THE ARNICUS MILL OF THE HOMESTAKE MINING CO., LEAD, S. D.

Again referring to Schmitt, a table of Rand stamp duties is given, to which I have added a column to show the relatively slight variation in the amount of fines produced when crushing through screens of different apertures. The table checks my own observations as to tonnage, and also shows South African experience in crushing pyritic banket ores.

TABLE II. RAND STAMP DUTIES

Screen		Tons per Stamp per Day Running Weight of Stamps		Grading			Tons per Day of of —90 Mesh
Meshes per Sq.In.	Aperture, In.	1,400 Lb.	1,250 Lb.	+60 Mesh	+90 Mesh	—90 Mesh	
9	0.27	15	13.4	62%	10%	28%	4.2
16	0.20	14	12.5	59	11	30	4.2
25	0.15	13	11.6	56	12	32	4.15
64	0.09	10	8.9	47	14	39	3.90
100	0.07	9	8.0	43	14	43	3.87
600	0.028	7	6.3	31	16	53	3.72
1,000	0.02	6	5.4	22	18	60	3.58

Height and Frequency of Drop—These are mutually related. The stamp should be in action constantly. Shorter drop permits of an increased rate. The tendency of using heavier stamps and of giving more atten-

tion to the preparation of the stamp feed favors relatively short drops, as under such conditions the stamp is still able to shatter the largest pieces of feed, and the added number of blows which can be delivered becomes a clear gain. Deep discharges are justified only when fine crushing is sought.

Stamp-Mill Flexibility of Value in Small Installations

The stamp mill is well suited to small installations, the flexibility already mentioned being a most valuable asset under such circumstances. The ability to take a rather coarse feed saves expense in the coarse-crushing equipment, and irregularities in the nature of the ore, which are more marked in such installations than in large-scale operations, are more readily accommodated.

Here is one point which may be advanced against the ball mill: If theoretically ideal conditions for grinding are obtained by feeding ore of certain size to a mill in which ball size, load, speed, and other factors are correctly adjusted, the reduction of a smaller quantity of ore, implying the use of a mill of smaller diameter, will introduce an entirely new set of conditions. These new conditions, by the terms of the proposition, cannot be ideal. Compromises are inevitable. They must have a bearing on the efficiency of the installation, whether or not they are great enough to turn the scale in favor of one machine or the other. The same problem arises with any machine of high capacity. In a more extreme degree the same circumstances affect the value of all laboratory investigations of grinding, in that the scale of all elements entering the tests is reduced, excepting only the size of the rock particles.

The future of the stamp mill will be in the field indicated by South African practice. Where amalgamation is practiced, the stamp will always be a favorite machine, but amalgamation can be successfully practiced without the use of a stamp mill. High output through coarse screens will be the object sought, and the faults of the multiple mortar, already mentioned, indicate one limiting factor of advance in this particular. The increasing difficulty of removing coarse material from the mortar, except with a greatly increased volume of water, will place another limit on expansion in this direction. The Nissen stamp, with its circular mortar and screen, will gain in favor, despite its increased installation cost, as it improves these conditions. Unless the difficulty of discharging coarse material should be so great as to prevent, an opportunity would seem to be offered to crush with stamps, discharge through a coarser screen than is sanctioned by present gold-milling practice, and then substitute the ball mill for the tube mill as the fine-grinder.

In conclusion, a few current reports of the work done by stamp mills may be pertinent.

Nipissing—(Johnson, A. I. M. E., Vol. 48, p. 3.) Stamps, 1,500 lb. Five on a camshaft, two shafts driven from a 40-hp. motor through countershafts. Actual power consumption, 31 hp. Drop, 8 in. Rate, 96 times per min. Dilution of pulp, 7: 1. Screen, 3 x 3, or 2 x 2. Stamp duty, 6.7 tons. "An extremely hard and tough ore." Screen analysis of tailings, on 20 mesh, 55 per cent; 50 to 100 mesh, 24 per cent; through 200 mesh, 17 per cent.

Belmont—(Jones, ibid, Vol. 42, p. 105.) Stamps, 1,250 lb. Ten on a camshaft, two shafts driven from 60-hp. motor through countershafts. Actual power consumption, 52.6 hp. Drop, 6 in. Rate, 104 times per min. Dilution, 5: 1. Screen, 4 x 4, and 6 x 6. Stamp duty, 8.88 tons. Screen analysis of tailings on 20 mesh, 29 per cent; 20 to 100 mesh, 40 per cent; through 200 mesh, 24 per cent.

Homestake—(amalgamating)—Stamps, 900 lb. Ten on a camshaft, each shaft driven direct from 25-hp. back-geared motor. Actual power consumption, 20.4 hp. Drop, 10 in. Rate, 89 times per min. Dilution of pulp, 10.5: 1. Screen, No. 8 diagonal slot (aperture, 0.022 x 0.5 in.). Stamp duty, 4.5 tons. Depth of discharge, 8 in. Screen analysis of tailings, on 50 mesh, 8 per cent; 50 to 100 mesh, 17 per cent; through 200 mesh, 53 per cent.

Homestake (experimentally)—Same stamps and adjustments, except: Depth of discharge, 1 in. Screen, 3 x 3. Stamp duty, 8 + tons. Screen analysis of tailings, on 20 mesh, 37 per cent; 20 to 100 mesh, 28 per cent; through 200 mesh, 24 per cent.

Santa Gertrudis—(Rose, *Trans. A. I. M. E.*, Vol. 55.) Stamps, 1,550 lb. Ten on a camshaft, twenty being driven by a 65-hp. motor, through countershaft. Actual power consumption, about 70 hp. Drop, 7½ in. Rate, 102 times per min. Dilution of pulp, 10:1. Screen, 3 x 3 mesh and 4 x 4 mesh. Stamp duty, 21.1 tons.

New Modderfontein—Nissen stamps, 2,000 lb. weight. Four from a camshaft, two shafts driven by 50-hp. motor. Screen, 3 x 3 mesh. Stamp duty, 30 tons.

Flotation of Chalcopyrite a Simple Problem At the New Loon Lake Mill

The design of the Loon Lake Copper Co.'s plant was discussed by L. A. Grant at the flotation conference held at Moscow, Idaho, last month. This mill, which is about fifty miles north of Spokane, Wash., was built by W. L. Ziegler. Although only a small plant, it has attracted considerable attention, owing to its compactness and simplicity. The ore is a chalcopyrite in clean quartz—an ideal material for separation. Remarkable results are reported, upward of 95 per cent recovery at times having been made. The flow sheet of the plant is extremely simple, consisting of a 10 x 15-in. Blake crusher, followed by a 24-in. Symons disk crusher, feeding to two 4 x 4-ft. cylindrical ball mills crushing to minus 65 mesh. The entire pulp then goes to a Ziegler flotation machine, producing clean concentrate in one operation. No. 5 distilled pine oil is used.

The New Iron Cap Mill

The new milling plant of the Iron Cap Copper Co., at Globe, Ariz., is expected to start early next month. The use of rod mills makes this a most interesting installation. The flow sheet will be simple, both primary and secondary grinding being done with rod mills. The pulp will be put over roughing tables after the initial grinding, and the re-ground material will be treated in pneumatic flotation cells. Drag classifiers will then remove the sands for final tabling. Most of the copper in the ore treated by the new plant is in the form of bornite, and a 95 per cent recovery is confidently expected.

Cement Bottoms for Pneumatic Flotation Cells

Rigid Air Mats Have Superseded Canvas in the Flotation Plant of the Ray Consolidated Copper Co. and Have Proved Exceedingly Satisfactory—Some in Use for Two Years—Occasional Cleaning All That Is Necessary

BY H. C. MCCRAE

Metallurgical Engineer, Ray Consolidated Copper Co., Hayden, Ariz.

Written exclusively for *Engineering and Mining Journal*

AS A RESULT of experimental work conducted in an effort to replace the canvas mats of pneumatic cells with a more durable material, the Ray Consolidated Copper Co., at its mill at Hayden, Ariz., has developed porous concrete bottoms. The first of these were poured in place in September, 1917, and a large number are still in use and in good condition. Although a number of the concrete mats have been replaced, owing to changes or alterations in the machine, only seven have required removal on account of wear.

The cells used have inside dimensions of 35½ x 51½ in. Two methods of installing the mats have been successfully employed by the company. The first was to construct the porous mat in place, according to the following directions:

Build the forms in each cell of the machine so as to give a wall of ordinary dense concrete 4 in. wide and 8 in. deep. When the concrete is set, remove the forms and pour the floor of the cell with the same dense concrete to a depth of 4 in. Round pebbles varying in size from 1½ in. to 2½ in. are now placed in the floor of the cell to a depth of approximately 4 in., and the top is covered with small pebbles about ½ in. in diameter to obtain a level surface. This pebble filling not only serves as a good foundation upon which to build the overlying porous mat, but also allows sufficient space to equalize the air pressure.

The proper size of sand for use in making the air mats can be secured from the fine-crushing department of the ordinary concentrator. The sand should be as free as possible from inclosed mineral; therefore, tables treating a sand product that passes 10 mesh, with very little fines, reject tailings suitable for these mats. A hard siliceous sand that contains a considerable amount of quartz is preferable. Such sand is generally of irregular fracture, and is much better suited for this purpose than the sand from soft ores or the ordinary rounded river sand. The sand is dried for screening.

An 18-mesh copper-wire window screen placed and shaken on a horizontal plane is first used. The undersize from this screening is now passed over a screen of the same size placed at a 45-deg. angle. This will remove the fines and give a clean sand of uniform size. Five parts of this sized and dry sand are thoroughly mixed with one part of dry portland cement. This mixture is now dampened by sprinkling on water with a brush. Care should be taken only to dampen and not to add excess water, as the problem is to get the cement to adhere to the sand and dampened sufficiently to make the mass harden. Re-enforcing is put in the dense concrete sides, and ¼-in. or ⅜-in. iron rods, placed about 6 in. apart each way, are used in the top porous mat for re-enforcing.

The mixture for the porous mat should now be spread over the bed of pebbles in the cell to a depth of about 3 in. A beveled corner strip, 1½ x 2 x ½ in., should be placed around the inclosing sides of the wall, to be removed later, and dense concrete poured in the space. This, when set, should calk any air leak along the sides of the mat. The mixture should be well tamped with a wooden mallet as filled, and surfaced with a wooden float. A metal trowel should not be employed as a surfacing tool.

After twenty-four hours, sprinkle sparingly with water from a brush, taking care not to get too much water on any one spot. This sprinkling operation should be repeated several times each day for three or four days, then a spray from a hose may be employed, and the concrete given plenty of water. About ten days is required for the porous mat to set. Some of the machines with this porous mat made as outlined have been combined into one large cell; others have been divided into three separate and distinct compartments by means of sheets of No. 16-gage iron partitions placed in dense concrete in the floor of the air chamber and extending to the surface of the mat. The number of compartments into which each cell is divided regulates the number of valves to be used for the adjustment of air.

In recent practice, however, it has been found more satisfactory to replace the walls and bottom of the dense concrete air chamber with a metal pan, which permits the making of the porous mats at any convenient place and reduces the time required for replacement. This metal pan is constructed in such manner as will permit of its being placed in the 35½ x 51½-in. cells with ease. It is divided into three compartments, and each compartment into two sections to reduce the necessary size of the porous blocks. The pan is about 7 in. deep, with a 1-in. angle iron, serving as a support for the porous mat, riveted on the sides and between the sections and compartments, 3 in. from the top.

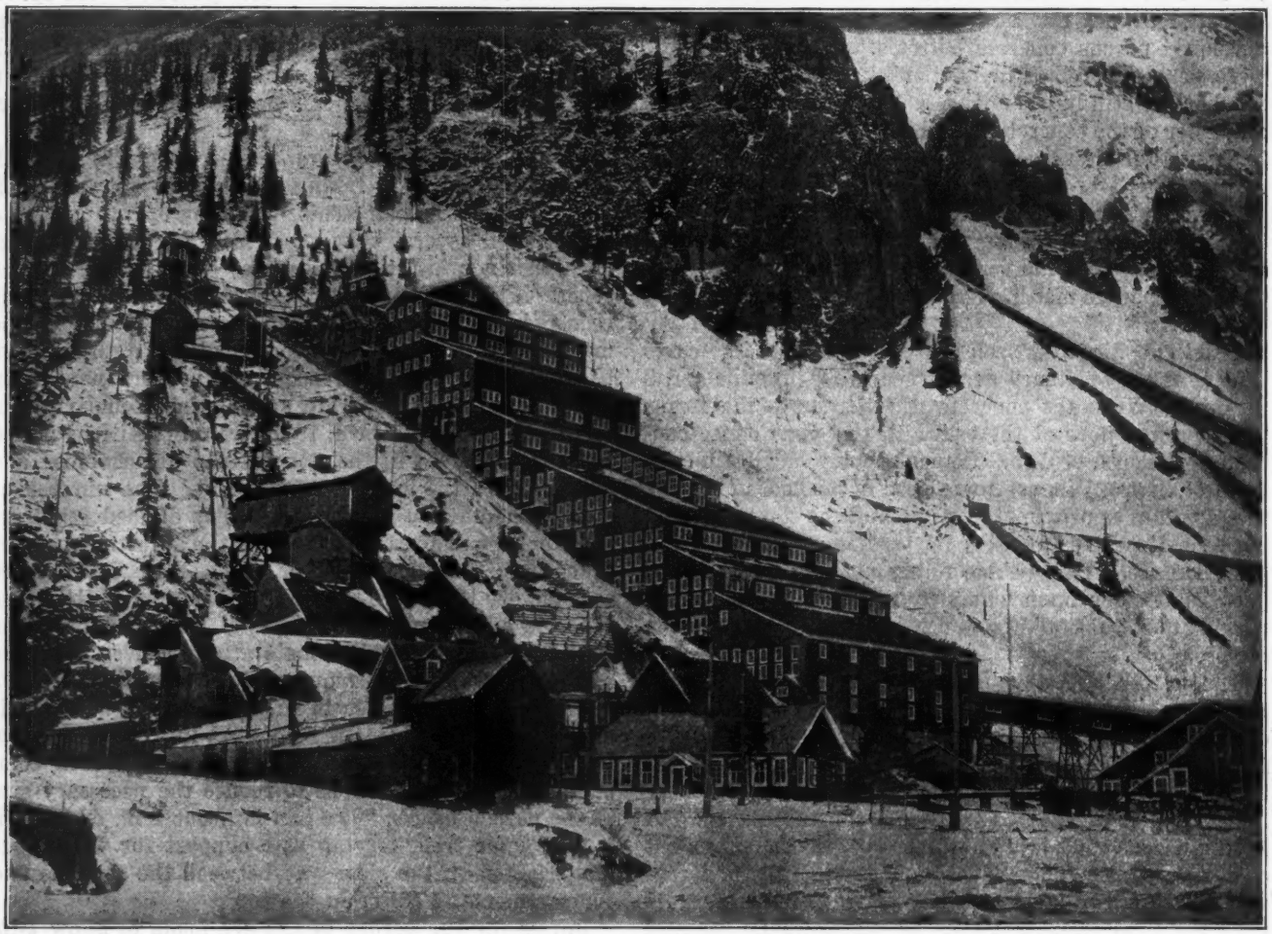
Forms for the porous blocks are made to allow ½-in. space between the porous mat and the sides of the pan or the angle iron, which space is to be filled with neat cement. The same specification for these air mats is followed as previously described. The re-enforcing for the porous blocks consists of two 23-in. and three 10½-in. iron rods, ¼-in. in diameter, and all rods are wired securely at each cross. The mixture is tamped in toe forms and allowed to set for at least seven days, then stripped and placed in the metal pans. The forms are 3 x 10¼ x 22¾ in. inside, which permits of slight extension of the re-enforcing rods into the neat cement.

Experience with the operation of the air mats shows that about every sixty days the machine must be shut down and the mats thoroughly scraped with a small hoe, and also brushed well with a wire brush. This is necessary to remove a slight coating of iron carbonate that forms on the top surface.

The Sunnyside Mining & Milling Co.

New Mill Promises To Add Materially to Colorado Mineral Production During 1920—Complex Zinc-Lead Ore Is Successfully Treated by Selective Flotation Methods Using Minerals Separation Equipment

THE declining production curve marking the mineral output of Colorado for the last three years should take a decided upward turn during 1920, and among the factors that promise to contribute materially will be the operations of the Sunnyside Mining & Milling Co., a subsidiary of the U. S. Smelting, Refining, Mining & Exploration Co., which is operating near Eureka, in San Juan County.



EXTERIOR VIEW OF THE 600-TON SELECTIVE FLOTATION PLANT

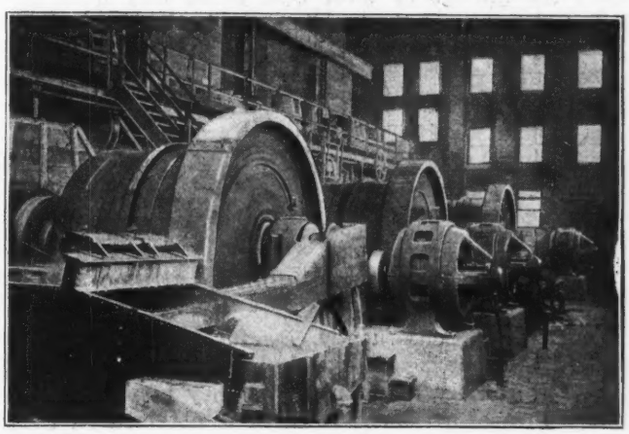
The Sunnyside mines were taken over by this company in 1917, and a vigorous plan of development was at once begun in connection with the construction of a milling plant of 600 tons' daily capacity at Eureka, 3½ miles from the mines. The mines and mill are connected by a tramway having a capacity of 350 tons in eight hours.

The mill was completed and put in operation in April, 1918, and during that year the mines were credited with a production of $1,045,078. In April of last year a fire at the mine destroyed the operating plant, bunk house, boarding house, and all surface equipment, and production practically ceased at the mines until December. Among the new buildings constructed is a three-story bunk house, with beds for 200 men; a boarding house to shelter 150 men, both with steam heat and hot water throughout; a commissary building with club features, and a theater, a company building, a hospital, and a store. With the completion of the new buildings at the mine, late last year, operations have been gradually extended, until the output has now reached approximately 500 tons daily, and about 350 men are employed at the mine and mill. Electric power is furnished by the Colorado Power Co.

The ore is similar to other ores of the San Juan district, a complex sulphide carrying gold, silver, lead, copper, zinc, and iron, intimately mixed with a gangue of quartz and rhodonite. The average mineral content as reported to the Bureau of Mines is: gold, 0.15 oz.; silver, 7 oz.; lead, 7 per cent; copper, 0.60 per cent; zinc, 9 per cent; and iron, 3 per cent. The mill is a licensee of Minerals Separation, and some excellent work on selective flotation has been done.

The mill is at Eureka, on a branch of the Denver & Rio Grande R.R. The ore is crushed at the mine to pass a 3-in. ring, then conveyed over a Trenton tramway to

the mill and dumped into three bins, each of 1,300 tons' capacity. From the bins it passes into three Marcy mills, each in closed circuit with a 6-ft. Dorr classifier, where it is crushed to 28 mesh. Each mill is directly coupled to a 225-hp. motor and has a capacity of 400 tons in twenty-four hours. (When running to full capacity, one mill will be in reserve and two in operation.) From the Marcy mills the ore passes into five tube mills, using rhodochrosite from the mine as pebbles. Three

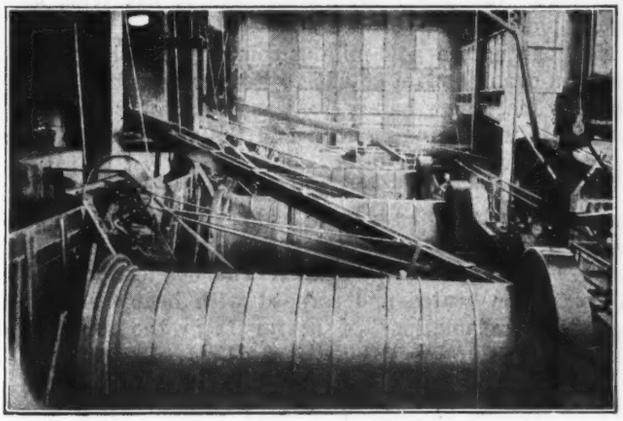


BALL-MILL DEPARTMENT—THREE 8 x 6-FT. MARCY MILLS

mills are 4 x 15 ft. and two 5 x 14 ft. Each mill has a 6-ft. classifier. Seventy per cent of the pulp leaving the tube mills is minus 200 mesh.

The lead flotation unit has a capacity of 600 tons daily. It consists of one 6-cell, 24-in. Minerals Separation machine and one 6-cell, 18-in. M. S. subaërated machine. From the lead cells the pulp passes to the zinc-flotation machine, which consists of one 20-cell, 24-in. Minerals Separation standard machine. Eleven Wilfley tables are installed below the flotation sections, six of which are used as pilot tables.

The lead concentrates go from the flotation machine to a 25 x 8-ft. Dorr thickener and are elevated to a



THE 5 x 14-FT. TUBE MILLS FOR REGRINDING

12 x 3½-ft. Portland filter, which discharges at 6 per cent moisture. The zinc concentrates pass from the flotation unit to a 28 x 12-ft. Dorr thickener, thence to a 12 x 9-ft. Portland filter, which discharges at 8 per cent moisture.

The concentrate from the filters is conveyed by two 12-in. belts to a steel bin of 1,000 tons' capacity, whence it is drawn off direct to the cars for shipment. About one hundred tons of concentrates are produced every twenty-four hours. The recoveries of gold, silver, lead, and copper being made in the lead concentrate, and of zinc in the zinc concentrate, are better than were indicated in the preliminary experiments, and little modification of the original laboratory flow sheet has been necessary.

Factors Affecting Zinc Consumption In Cyanide Practice

EXPERIMENTS have been conducted by H. A. White on how zinc consumption is affected by the concentration of cyanide, the alkalinity, and the amount of oxygen present in the cyanide solutions used in gold extraction. The results have been brought before the Chemical, Metallurgical and Mining Society of South Africa for discussion.

In a deaërated solution containing 0.75 mg. of oxygen per liter the solution of zinc is slow and of little importance, regardless of the strength of cyanide solution. In an aërated solution, however, the alkalinity of which was equivalent to 0.04 per cent NaOH, various strengths of cyanide made considerable difference, maximum solution of zinc apparently taking place when the KCN content was 0.02 per cent.

Electrolytic contacts increased the zinc consumption considerably. The carbon contact consumed about twice as much zinc as the lead contact, and the latter about twice as much as in the case of free suspension.

With free cyanide present to the extent of 0.03 per cent KCN, variations in alkalinity had no effect. With only 0.01 per cent of KCN present, however, the alkalinity had a marked effect and the amount of zinc dissolved greatly decreased as the NaOH equivalent was increased to 0.03 per cent. This was particularly evident with a lead contact. In a solution free of cyanide, both with lead contact and in free suspension, solution of zinc was practically nil with alkalinity equivalent to 0.04 per cent NaOH. The experimental work showed that the alkalinity in cyanide solutions might be run up to 0.03 per cent NaOH without danger of interference with precipitation.

Other experiments were made, all of which showed the necessity of extremely close regulation of the cyanide strength and alkalinity, as well as the total absence of oxygen, in order to approach the ideal of consuming only as much zinc as would correspond with the gold and silver precipitated. About 0.1 lb. of zinc is consumed on the Witwatersrand per ton of solution carrying 0.1 oz. of gold. This consumption is roughly divided as follows:

	Per Cent
Gold and silver precipitation	1.2
Combination with dissolved oxygen	49.0
Evolution of hydrogen	4.8
Taken for clean-up	33.0
Used to precipitate lead in "dipping," waste in cutting, forming ZnS coating, etc	12.0

R. S. Handy, Superintendent of the Bunker Hill and Sullivan Mills, believes that if the colloidal or slimy material can be eliminated from a pulp, and then the non-colloidal portion sized carefully, much better results can be secured than usual, both by gravity concentration and by flotation. Indeed, Mr. Handy holds that once the colloidal material is out of the pulp, it makes little difference which of the two methods of concentration is used.

Flotation of Molybdenite

Milling Practice of the Dominion Molybdenite Co. in Quebec Gives 90 per Cent Concentrate With 98 per Cent Recovery

BY CHARLES E. OLIVER
Research Chemist, Trail, B. C.
Written exclusively for *Engineering and Mining Journal*

THE following is a description of the milling process used by the Dominion Molybdenite Co. in concentrating molybdenite ore at Quyon, Quebec. On account of the condition of the market, this company closed down its plant in March, 1919, but as excellent results were secured, the process employed will no doubt be of interest to many millmen.

The ore is mainly a quartz diorite, and the molybdenite is disseminated through the rock in flakes varying in size from minute specks to leaves an inch or more in diameter. The distribution through the rock is fairly uniform, though in spots, several hundred pounds of ore may be taken out assaying 50 per cent MoS_2 or better. However, these spots constitute only a small percentage of the total milling ore. Sorting is not done, as the orebody is walled in on either side by barren red cyenite.

The average ore assays 0.5 to 0.75 per cent MoS_2 and also carries pyrite, which is generally in excess of the MoS_2 and at times runs as high as 3 to 5 per cent. The ore contains little copper, as the concentrates carry only 0.1 per cent.

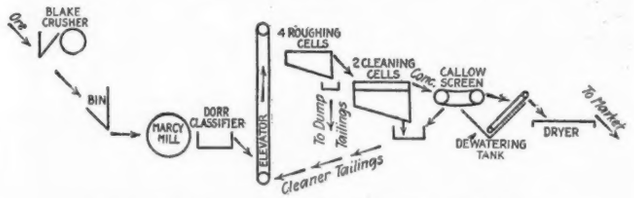
Reduction to 2-in. size is accomplished by a Blake crusher, the product going to a 6-ft. Marcy mill in closed circuit with a Dorr classifier, the overflow passing 40 mesh. A mixture of No. 5 General Naval Stores pine oil and kerosene is fed into the ball mill with the ore. As a result of grinding the oil with the ore, a large percentage of the MoS_2, as soon as freed from the gangue, floats out of the discharge in large flakes and materially aids subsequent treatment. These masses at times measure ½ in. in diameter.

From the ball mill the pulp is elevated to a set of Callow cells. The capacity of the mill is 150 tons in twenty-four hours, and four single cells are capable of handling this tonnage. The rougher concentrate assays 10 to 15 per cent MoS_2 and about the same in FeS_2, the remainder being fine gangue, which is carried over mechanically by the froth. This concentrate falls directly to the two cleaner cells.

The cleaner cells are operated differently from the usual practice. Sides are put on the cells to prevent the froth overflowing and to cause it to build up to a depth of 14 to 18 in., and in this froth a selective action takes place. The gangue settles out of the sulphides; also, most of the pyrite falls out. The upper stratum of froth, being the richest in MoS_2, is allowed to discharge through an opening 1 in. wide in the end of the cell. The concentrate from the cleaners assays from 60 to 70 per cent MoS_2, and the particles are well flocculated, due to the quiet prevailing in the cells. The blanket bottoms must be kept well cleaned and all boiling avoided, otherwise the grade of concentrate will be reduced.

The cleaner concentrate falls to an 80-mesh Callow screen and is washed with a water spray to remove the last of the pyrite and adhering gangue. The concentrate is removed on the under side of the screen by a spray of water, and falls into a dewatering tank from which a scraper continuously removes it to a drier. This finished concentrate assays from 85 to 95 per cent MoS_2 and 2 to 3 per cent FeS_2, the remainder being gangue.

The cleaner cells operate in closed circuit; the fines from the Callow screen join the tailings from the cleaner cells and flow into the elevator boot, to be thoroughly mixed with fresh pulp. This results in a material reduction of the amount of oil necessary, and aids the recovery. The restricted overflow of the cleaner cells causes the tailings of these cells to be very high in MoS_2, and results in the building up of sulphides in the



FLOW SHEET, DOMINION MOLYBDENITE CO.

whole circuit. Consequently, careful manipulation is required in operating the rougher cells to maintain an even froth, otherwise a large loss may result in the tailings in a short time. A check is obtained on the operation by an automatic sampler placed in the tailing launder.

The results obtained are remarkable, as the regular monthly mill sheet shows: Feed, 0.7 per cent MoS_2; concentrate, 90 per cent; tailings, trace. Oil consumed, 0.5 lb. pine oil and 1 lb. coal oil per ton of ore. The recovery rarely falls below 98 per cent over a month, and temperature changes are without effect on the operation or the grade of the product.

Absorbed Gold

BY MARK R. LAMB

A clipping from a mining publication states that $68,324 in gold was obtained from plates which had "absorbed" the gold. Of course this is not true, as copper plates do not absorb gold.

Not long ago, a gold-mining company in Chile purchased a cyanide plant to add to its amalgamation mill. The new machinery had arrived and was being erected, but funds were running low, and the venture was on the ragged edge of failure.

A visiting engineer casually examined the old battery plates, which had been in use for many years, and was astonished to note that they were covered by a heavy layer of hard amalgam. The suggestion that the plates be heated and scraped with bent files was met with exclamations of horror from the millman, who wanted to protect the silvering!

He was finally persuaded that no harm would result, and thousands of dollars were recovered from the plates from two five-stamp batteries; sufficient to complete the cyanide plant and start operation. As kettle after kettle of hard, dry amalgam was scraped loose and gathered, the superintendent's eyes opened wider and wider. The older employees could not be kept away from the interesting sight, and, finally, everyone who could find room was busily engaged in the task, incidentally commenting excitedly at the results. Absorbed gold, like spirit manifestations, is an interesting phenomenon.

The Economics of Ore Concentration

Discussion of Previous Papers by Watt and Handy—Metallurgical and Economic Efficiency —Determination of Zero Value as Affected by Smelter Contracts— Use of Formulas—Table Adjustments

BY R. T. HANCOCK
Manager Nigerian Tin Corporation, Ltd., Jemaa, North Nigeria

Written exclusively for *Engineering and Mining Journal*

SUCH articles as those by A. P. Watt and R. S. Handy which have appeared in recent milling numbers of *Engineering and Mining Journal* are of great value as serving to dispel the clouds of ignorance which prevail about the phase of concentration which they discuss. Here in Nigeria, we sell our concentrate under a smelter contract that provides for an increase of 5s. a ton in the returning charge for every unit of metallic tin below 70 per cent, and for a reduction of 2s. 6d. for every unit above 70 per cent. I have heard it gravely argued by a man in a leading position that it does not pay to dress concentrate to over 70 per cent, as one loses half a crown per ton by so doing. One of the largest producers has ordered that the concentrate shipped must go 71 per cent, no more and no less, and if the concentrate produced happens to be better, as it can easily be, then it is diluted with tailings. I have often wondered at the selection of this particular figure, and can only think that it arises from the use of an approximate method of assaying that I introduced here in 1912, in which the percentage content of metallic tin can be derived by noting the difference in the readings of a burette partly filled with water before and after a certain weight of the sample has been introduced. The conventional weight is 100 grams and a replacement of 15 c.c. corresponds to 71.5 per cent of metallic tin, so doubtless the metallurgist's work is facilitated by the adoption of this standard grade.

Mr. Handy hopes that his article will evoke comments from lead operators, and although I know nothing about that metal, I will venture a few observations. I will take his instance of 100 tons of mill feed assaying 10 per cent lead in the form of galena, the smelter contract providing for the payment of 4c. per lb. on 90 per cent of the lead content of the concentrate, less $7.50 for freight and treatment.

Mr. Handy gives a series of cases showing the net return from the shipment of varying tonnages and assays, the one varying more or less in inverse ratio to the other, and a further examination of the saving made by reducing the tonnage shipped and correspondingly increasing the assay, as compared with the case where the mill feed is shipped without treatment. The figures he obtains from his calculations are not meticulously precise, and in his subsidiary examination of each case he does not appear to have observed that what he calls the gain (over the shipment of the mill feed in its original condition) should be in every case $30 more than what is declared to be the profit in the other aspect of the case he presents, $30 being the loss on shipping untreated.

Lack of exact concordance in Mr. Handy's figures would seem to indicate unfamiliarity with a simple method of formulating a smelter contract, which makes it possible to make such calculations with little trouble and less liabilty to error. In the particular instances chosen, the formula can be expressed: Net smelter value per ton = $0.80 × 0.90 Pb assay — $7.50, where $0.80 is the price paid per unit (of 20 lb.), 0.90 the percentage paid for (expressed as a decimal part of unity), and $7.50 the amount of the freight and treatment charges per ton.

This formula can be thrown into the form: Net smelter value per ton = $0.72 (Pb assay — 10.416 per cent).

It is now immediately apparent that the shipment of a parcel assaying 10.416 per cent of lead will have no net smelter value at all, as its value is just sufficient to defray charges, and, further, it follows that the economic peak is more nearly attained if any parcel ready for shipment to the smelter can be re-treated and a product assaying 10.416 per cent or less removed from it, the cost of such treatment being neglected in this argument, as, indeed, Mr. Handy excludes it in arriving at the net smelter return, but deducts it separately.

The whereabouts of the economic peak in the graph of net smelter return plotted against tons shipped to smelter, or, rather, against the number of tons of concentrate obtained from the treatment of 100 tons of mill feed, or the percentage concentration, is, therefore, of no particular concern to the mill manager. He can easily see whether he has reached it, or he can approach it more closely, by an examination of his final products. In the same way tailings are not tailings for final rejection so long as it is possible to re-treat them and extract something assaying more than 10.416 per cent. In this case, also, allowance must be made for the cost of such re-treatment. Although I have suggested that Mr. Handy is not acquainted with this particular mathematical treatment of the question, he is undoubtedly familiar with the final principle, and his practice seems to be to set his machines so that they will produce at one operation either a final concentrate or final tailings which may not be expected to respond to re-treatment.

THE MEANING OF "ECONOMIC EXTRACTION"

The term "economic extraction" which Mr. Handy uses is new to me, and I cannot say that I like it much, because if it came into general use there would be a good deal of doubt as to what it actually meant. Mr. Handy defines his own use of it, but even here he misapplies it, because he derives it from the net smelter value, which he has obtained without reckoning the cost of milling. If he could conceal the cost of milling altogether, there would be nothing to prevent his raising the economic extraction, as he defines it, to anything short of 80 per cent that he pleases. But such extraction would cease to be economic. He is further unfair to himself in that he sets the gross value of the feed at $800, and calls his economic extraction the ratio of the net smelter return to that, expressing it as a percentage. The utmost he could ever obtain by shipping the whole of the galena in 100 tons of mill feed absolutely free from gangue

would be $641.70, and I would prefer to put the gross value of the feed at this figure rather than at the unattainable one. As it is, Mr. Handy appears to understate his economic extractions by about 20 per cent.

A smelter contract can generally be expressed by a formula of the type given, which is the equation of a straight line, and, if it cannot, an approximation in this form can generally be made to cover the region around the usual grade of concentrate shipped. If penalties or premiums are provided for in a contract, it will usually be necessary to compound subsidiary equations, but a little ingenuity and some knowledge of graphical methods of representing functions will do a great deal toward evolving the important figure, which is the assay of a parcel which will have no salable value. It may not be sufficient, though, to evolve this figure simply by working back through the contract. If penalties per unit below standard increase as units get less, a parcel which under the contract would have no value if shipped alone might have a value if it were a small one and mixed with higher-grade ore.

Mixing Low-Grade Material With Rich Concentrate May Be Advisable

When I had written the foregoing sentence I was horrified to find that I had apparently suggested that a parcel of less than zero value might be smuggled through the smelter's sampler by mixing it with the higher-grade ore, and increase the net value of the whole shipment. Many people would consider this a fallacy, but it appears possible to do it successfully when the plot of net smelter returns against assays is a curve instead of being a straight line. In such a case, the assay of a parcel which it will not pay to mix with average-grade shipping concentrate, and conversely the assay of tailings which may be advantageously removed from such concentrate, is found by drawing a tangent to the curve in the region of the grade of average shipping concentrate, and observing where this cuts the ordinate of zero value. As the operation of a smelter contract will usually be expressed by a series of straight lines joining points lying on a curve, all that is necessary is to produce the particular straight line covering the region of average shipping concentrate. The amount of low-grade material which may be added must not be sufficiently large to throw the assay off this straight one on to the next below.

Over a year ago I published[1] a series of formulæ designed to express the metallurgical efficiency of an ore-dressing operation. They are equally applicable to any operation where the attempt is made to segregate into two different lots any two distinguishable qualities originally occurring mixed, such as in screening.

Useful derivatives of the fundamental formula are:

$$\textit{Percentage metallurgical efficiency} = 100 \times \frac{\%\ \textit{recovery} - \%\ \textit{concentration}}{\%\ \textit{of waste in feed}}$$

or,

$$100 \times \frac{\%\ \textit{concentration} \times (\textit{enrichment ratio} - 1)}{\%\ \textit{of waste in feed}}$$

or,

$$100 \times \frac{\%\ \textit{concentration}\ (\textit{assay of conc.} - \textit{assay of feed})}{\textit{assay of feed}\ (100 - \textit{assay of feed})}$$

It would not appear that any attempt to express the percentage efficiency of an ore-dressing operation had been made before, and the formulæ have been published too recently to have met general acceptance. It follows from them that the inclusion in the concentrate of any material of lower assay than the feed decreases the efficiency of the operation, and so does the inclusion in the tailings of any material assaying higher than the feed. Further, material of the composition of the feed may be shifted from the concentrate to the tailings, or vice versa, without the efficiency being affected thereby. In other words, an operation resulting in the production of low-grade tailings and a low-grade concentrate may be of similar efficiency to one producing a high-grade concentrate and rich tailings.

Applying the Formula When Middlings Are Produced

Where a middling product, or more than one, is made in addition to concentrate and tailings, efficiencies can be calculated by treating each of the products as if it were a concentrate, and the only one produced. Products having a higher assay than the feed will have positive efficiencies, and those lower than the feed, negative efficiencies. If every product is regarded as a tailing product, the figures obtained are the same, but the positive and negative signs are reversed. The sum of the efficiencies for the total number of products will be zero.

The efficiency of an operation producing a middling product having the same assay as the feed is zero for that particular product. The greater the sum of efficiencies of similar sign, the greater is the efficiency of the process by which they were produced at one operation, or perhaps it would be more correct to say, the more tractable the original material has proved to be. The formula can be applied in testing a single process, or the operation of a machine, or the performance of the whole mill over any stated period. Where the ore contains more than one element of value, efficiency calculations can be made for each.

In 1918, the Bunker Hill & Sullivan mined and milled 387,027 tons of ore carrying 10.65 per cent lead and 4.32 oz. silver; 84,170 tons of middling and concentrate carrying 45 per cent lead and 16 oz. silver were produced and shipped to the Tacoma smelter, so that the efficiency of the milling operations over the period was 78.52 per cent as regards the lead, and 58.8 per cent for the silver. The recovery of the lead was 91.89 per cent, and of the silver 80.55 per cent.

The efficiency of concentration in the Cornish tin mills and in the copper plants of the Southwest is about 65 per cent on the average.

These formulas take no account of the economic aspect, but solely of the metallurgical efficiency. In milling the 10 per cent lead ore mentioned, with sole regard to metallurgical efficiency, as against milling it for maximum net smelter return, the operator would aim at excluding from his finished products any product assaying more than 10 per cent in the case of the tailings or less than 10 per cent in the case of the concentrate; whereas, for maximum smelter return, the figures would be in each case 10.416 per cent. The operator concerned only with the metallurgical efficiency of his mill, therefore, tends to keep lower-grade middlings in circulation.

The closeness of the figures is due to various coincidences, and in many cases the divergency between the best metallurgical practice and the best commercial practice would be wider. In the present case, where

[1] "The Rating of Concentration Tests," *Mining Magazine*, September, 1918.

it makes so little difference, one way or the other, it is not easy to see what would happen, and any desire to probe further is curbed by the fact that the actual assay of the Bunker Hill & Sullivan ore is over 10.416 per cent, rather than under.

I suggest, therefore, to Mr. Handy that the metallurgical efficiency as calculated by the formulas I have given might usefully figure on his report sheets in addition to the "economic extraction."

A further derivative of the efficiency formula is:

Percentage metallurgical efficiency = per cent recovery of values in concentrate — per cent recovery of waste in concentrate.

Mr. Handy's "economic extraction" can be formulated as:

Per cent recovery of values in concentrate — k (per cent recovery of waste in concentrate), where the value of *k* depends on the smelter contract and on the standard of perfection chosen.

Should Metal or Mineral Be Considered

It will be noticed that in the formulas given earlier, it makes no difference to the upper part of the expression whether recovery or enrichment is reckoned on the valuable mineral in the ore, or on the valuable element which that mineral contains. The lower part of the expression is, however, affected by such choice, but the relative values of results obtained either way are unaffected.

It is usually more convenient to reckon in terms of the metal, as this is directly given by the assays, and, indeed, the actual composition of the mineral itself may be doubtful. The adoption of the metal as the basis simply sets the 100 per cent maximum as the obtaining of the pure metal free from any admixture of anything else. This is, of course, an impossibility by any ordinary ore-dressing process. In my own practice, concerned with tin ores originally assaying about 1 per cent, I usually neglect the lower part of the expression altogether, but with ores which assay several per cent in their natural condition it is better not to do this.

The value of *k* in the above formulation of the economic extraction, for the cases given by Mr. Handy, is 1.0467 for a maximum of $641.70 obtainable by shipping to the smelter the entire galena contents of the ore free from any admixture of waste.

It may be pointed out that the value of *k* in the formula I have given for obtaining the "economic extraction" is derived thus:

$$k = 1 - \frac{N}{M}$$

where *N* is the net smelter return obtained by shipping the ore in its original untreated condition, and *M* is the maximum return obtainable by shipping a completely recovered and concentrated product. Where *N* has a negative value, as will be usual, a loss being made on the shipment of untreated ore, this part of the expression will be a minus quantity and must be subtracted algebraically. Where it happens that the result of shipping the untreated ore is neither a loss nor a profit, but just clears realization charges, *N* will be zero, and the metallurgical efficiency formula and the "economic extraction" formula become the same.

With the same original assay of mill feed, terms of smelter contract, and rate of freight and treatment charges, the ratio of *N* to *M*, and consequently the value of *k*, are not affected by variations in the metal price. If the metal price rises, then the millman can afford to chase his values further, and should do so. If he does not, then, undoubtedly, the true economic extraction has decreased. But with "economic extraction" formulated as above, whatever world convulsions take place, as long as the metallurgical performance of the mill remains the same, the "economic extraction" is unaffected. This term "economic extraction," then, seems to be only another way of expressing metallurgical efficiency, in which special weight is given to the presence of waste in the products.

In writing of the extraction from a semi-finished product of something going more, or less, than 10.416 per cent, according as tailings or concentrates are being considered, I have failed to express my exact meaning. A parcel of ore at any stage of treatment, or before treatment, will have a definite "smelter value," which may be negative. The object of dressing the ore is to raise that value to a maximum by the elimination of waste and the saving of the valuable mineral. The value of the parcel from which a product assaying 10.416 per cent has been removed is neither greater nor less than that of the original parcel, and the labor expended in abstracting it has been thrown away, except from the point of view of subsequent operations on the product so abstracted. In the case of a concentrate, the value of the parcel improves as long as successive small increments of tailings which gradually increase in assay are being removed, until an increment is reached having an assay of 10.416 per cent. The sum of the successive increments so removed will not assay 10.416 per cent, but some less figure. Therefore, in writing of the abstraction of a product assaying 10.416 per cent, I hope I will be understood as referring to such an increment finally obtained. As De Morgan says, the language of the calculus has not kept pace with its requirements. In practice, the required result will be obtained, not by the repetition of operations effecting the removal of tailing products gradually increasing in assay, but by a single operation designed to remove at one step tailings having an assay equal to that of the sum of the increments removed by the other method.

Concentrating in One Operation Vs. Re-treatment

The practical question then arises whether it is possible to obtain at one operation the same result in all respects as by successive re-treatments, the ore being re-mixed between each treatment, but not otherwise changed in character. The answer would appear to depend on the nature of the operation. It is obvious that in panning, if the ore in the pan were worked off without stirring it up at frequent intervals, a very different result would be obtained.

Some results published by S. J. Truscott, professor of mining at the Royal School of Mines, London, obtained in the course of investigations into the dressing of Cornish tin ores, may be cited as throwing some light on this point. The figures are averages obtained from the treatment of slimes on the ordinary Cornish frame, or rather on an experimental frame of smaller size.

In Table I, Case 1, the ore was treated in three successive stages, as in usual Cornish practice, the recovery of 36.1 per cent being the product of recoveries of 54 per cent, 76 per cent, and 88 per cent in the

successive stages, the concentrations and enrichments not being given. In Case 2, the result was obtained in one operation, and in Case 3, by one operation feeding at twice the usual rate. The original ore is considered as assaying 1 per cent.

TABLE I. EXPERIMENTAL TREATMENT OF SLIMES

	Case 1	Case 2	Case 3
Enrichment ratio	7.6	7.0	6.8
Per cent recovery	36.1	35.7	33.6
Per cent concentration	4.76	5.10	4.95
Per cent efficiency	31.3	30.7	28.6
Per cent weight of tailings made	95.24	94.90	95.05
Assay of tailings, per cent	0.671	0.677	0.699

In a parallel investigation on mill ore ground to the condition of slime and framed, the results noted in Table II are of interest.

TABLE II. EXPERIMENTAL TREATMENT OF MILL ORE

	Case 1	Case 2	Case 3
Enrichment ratio	16.3	12.8	14.3
Per cent recovery	69.6	71.3	69.2
Per cent concentration	4.27	5.6	4.8
Per cent efficiency	65.3	65.7	64.4
Per cent weight of tailings made	95.73	94.40	95.20
Assay of tailings, per cent	0.317	0.304	0.323

Certain of the computations given above are made from data originally published in Bulletin 173 of the Institution of Mining and Metallurgy, and the assay of the ore has been assumed at 1 per cent throughout in the absence of details.

RE-TREATMENT OF TAILINGS INDICATED

It would appear that there is little profit in either method, but the cost of the single operation will naturally be less than of the one conducted in three stages. In the original paper, Professor Truscott proposes to re-treat the tailings from the last two cases, and gives figures of the extra recovery so obtained, suggesting that a marked improvement in the total recovery from Cornish ores would be effected by following the process he advocates of treatment at one operation, with tailings re-treatment. As the assay, and inferentially the physical nature, of the tailings in either case is practically the same, it is difficult to understand why a similarly increased recovery should not be obtained from the re-treatment of the combined tailings from the stage treatment. As the case stands, Cornish millmen do not practice such re-treatment, no doubt because of their experience that it does not pay, and, this being so, it is hardly likely that the re-treatment of tailings merely differing in their past history would alter matters.

Where slimes are being enriched by stages on revolving frames, the usual Cornish practice seems to be to re-treat the tailings from the last treatment, the concentrates made in producing these tailings going to the calciner.

The adjustments of a concentrating table fall into two classes. The first comprises the selection of the correct relation of the various functions, such as consistency of feed, rate of feed, amount of dressing, water, slope, length, and frequency of stroke, and others dependent on the type of machine. The second is the setting of the dividing line between concentrate and tailings. The first is secured by trial, the best result being the one giving the highest figure as calculated by one of the efficiency formulas given. With any set of conditions the efficiency will be affected by the point at which the division between concentrate and tailings is made.

With a table of the Wilfley type, for instance, where the assay of the material passing over any point on the edge of the table decreases more or less regularly as the point is taken nearer the tailings end, there is one point of division where the efficiency calculated from the products made is a maximum. The assay of the material escaping at this point will be the assay of the original feed. Suitable adjustments will give the maximum efficiency with which the table is capable of treating that particular ore. If, now, the table is operated with the dividing point between concentrate and tailings in this position, one of the canons of ore-dressing mentioned by Mr. Handy is violated, because rarely will it be that either the concentrate or tailings so apportioned can be regarded as finished products. With the Wilfley type of table, two points, one on each side of this position, can be taken, the material passing between them being regarded as a middling product, and concentrate and tailings both removed as finished products at the one operation.

With machines making only two products, the division point will be shifted one way or the other to enable one final product to be made. With tables of the Frue vanner type, the adjustment of the division between concentrate and tailings can be made only by altering one of the primary adjustments of the machine, and it is difficult to determine which to alter with the least disturbance to efficient performance.

The scope of the efficiency formula is, therefore, to enable the primary adjustments of the machines to be made to best advantage, whereas the smelter formula decides the point at which concentrate must be divided from tailings. At the root of this argument lies the assumption that, with a given set of primary adjustments, the relation of the efficiency obtained, with any setting of the division point, to the weight or percentage of concentrate produced with this setting, determines a curve which apexes with the division placed at the "feed-assay" point; and that this curve is not cut by the curve obtained with any other set of primary conditions, but that adjustments giving the maximum possible efficiency with the division in the "feed-assay" position will give maximum efficiency with the division in any position.

Finally, the experienced operator will not bother with a formula at all, but be guided solely by his knowledge of his ore, and will remove as middlings anything which he knows will profitably respond to re-treatment, and leave in anything which he knows will not.

One word more: It sometimes pays to give the mill superintendent a dollar less to spend, and send it underground to dig.

Microscope Should Be Used in Test Work

Intelligent use of the microscope in examination of heads, concentrates, tailings, and intermediate products, and also examination by the microscope of polished sections to show mineral association, is vitally important in flotation testing. The application of this work to certain of the zinc-lead ores of the Coeur d'Alenes has shown that in 200-mesh particles magnified to 1-in. diameter, particles of galena of the apparent size of wheat grains are imbedded in solid sphalerite, and at times similar areas of sphalerite are surrounded by galena. It is evident that almost nothing short of molecular dissociation can separate zinc and lead in such ores.

Flotation Practice of the Swansea Lease

Excellent Results Secured on the Chalcopyrite Ores by Grinding to 100 Mesh, Followed By Mechanical Agitation — Tailings Average Less Than 0.05 Per Cent, And Recovery Is About 98 Per Cent

BY LYMAN F. BARBER
Mill Superintendent, Swansea, Ariz.
Written exclusively for *Engineering and Mining Journal*

THE camp of Swansea is situated in northern Yuma County, Ariz., in the Harcuvar mining district. Swansea is the terminus of the Arizona & Swansea Ry., which connects with the Santa Fé system at Bouse, twenty-five miles away. This camp and the surrounding camps have been producing intermittently for many years, but development has apparently now been started in earnest.

Swansea Lease Incorporated, a Clarke interest, employing about 165 men, is working the Signal group of

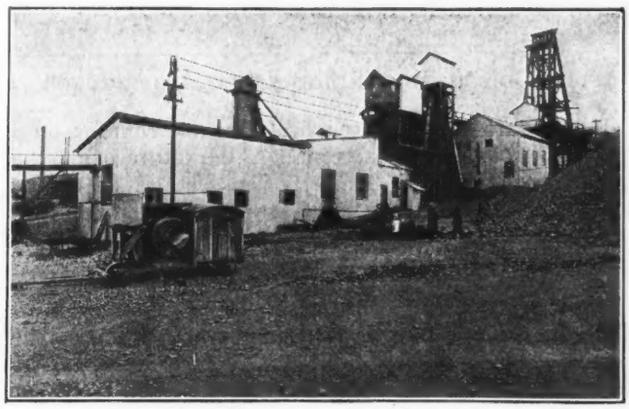


FIG. 1. NEW HEADFRAME AT NO. 7 SHAFT, CRUSHING PLANT, STORAGE BIN AND MILLING PLANT

claims. Development is proceeding rapidly, and new equipment, including a double-drum hoist, is being added to facilitate mining on a larger scale. The ore is specularite, carrying chalcopyrite in masses and finely disseminated particles, so that it averages from 1½ to 3 per cent of copper (2.27 per cent in February). Pyrite crystals are prescnt in small quantities. Most of these are found in granitic gneiss intrusions in the orebodies. The average ore is very soft, and slimes readily.

Hoisting is done through the new No. 7 three-compartment shaft, and the ore (about 250 tons per day) is trammed about 40 ft. to the crushing plant. Here the ore is dumped on to a grizzly with 2½-in. openings, about 90 per cent passing through. A 10 x 16-in. jaw crusher reduces any oversize to a 2½-in. ring. This machine also serves as a crushing medium for the crude trona (a combination of neutral and acid sodium carbonate), which is added to the 1,000-ton storage bin at the rate of 10 to 15 lb. per ton of ore.

The bottom of the mill storage bin has three openings, to which steel doors with adjustable gates are fitted. A Meese and Gottfried apron feeder, mounted on wheels, so as to be moved readily from one opening to another, is used to feed the ore on to a 22-in. conveyor belt. This belt discharges into a special trunnion feeder on the ball mill. A 6 x 6-ft. Allis-Chalmers ball granulator in closed circuit with a Dorr duplex Type "C" classifier is used for grinding. Two-inch chrome-steel balls at the rate of ⅛ to ½ lb. per ton of ore are added, a 12,000 to 14,000-lb. ball load being maintained at all times. The mill runs at 26½ r.p.m., and is driven by a 90-hp. motor.

The classifier overflow goes directly to the flotation division, and averages 90 per cent through 100 mesh. P. E. No. 1 oil, furnished by the Gilmore K. & K. Flotation Oil Co., Los Angeles, is fed into the trunnion of the ball mill at an average rate of ⅛ lb. per ton of ore. Many experiments have proved that this oil, used as a base, gives the best results on this particular ore. For a frothing oil on the primary cells, a 50-50 mixture of No. 5 G. N. S. steam-distilled pine oil and No. 8 pine-tar oil is used. No. 4 Barrett coal-tar creosote, mixed with No. 28 coal-tar oil (70-30) is added slowly to No. 8 cell. Frothing oils are fed at the rate of ¼ lb. per ton of ore. The classifier overflow is sent to cells Nos. 1, 3, and 4, and averages 24 per cent solids.

The flotation machine is a Minerals Separation Co.'s 18-in., 16-cell, low-level type, the main shaft having a speed of 390 r.p.m. A 55-hp. motor drives the flotation machine, middlings elevator, and concentrate elevator. The middlings elevator has 21-ft. centers, and the concentrate elevator, 58-ft. centers. The flotation machine handles an average of 255 tons of 24 per cent solid feed in twenty-four hours. Concentrates from the first seven cells are carried by a bucket elevator to a Dorr thickener. Oil is slowly fed to the last eight cells, and the

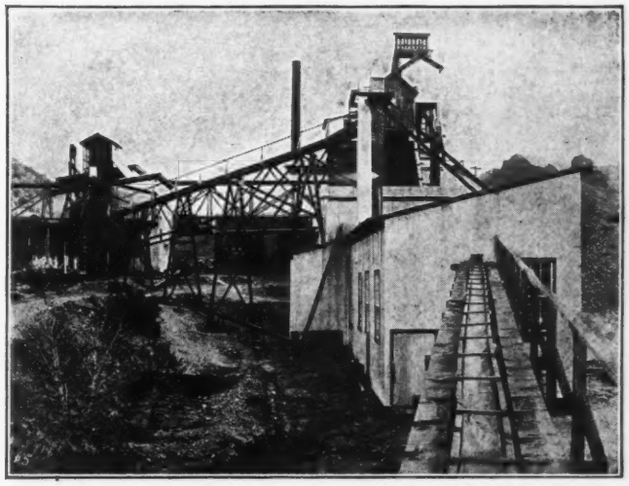


FIG. 2. REAR VIEW OF MILL, WITH CONCENTRATE THICKENER TANKS AND FILTER HOUSE AT THE LEFT

concentrate produced is very dirty. This concentrate is elevated and run into the classifier at a point near the overflow. This practice adds considerable to the circulating load, but reduces the copper in the tailings in a marked degree. The concentrate averages: Au, nil; Ag, 0.45 oz.; Cu, 23.12 per cent; insoluble, 10.4; Fe, 31.4; S, 28; CaO, 1.

Tailings are sampled every fifteen minutes at a point about twelve feet from the machine discharge. A check sample is cut from the tailrace at a point about 200 yd. below the mill. So far, considerable difficulty has been experienced in having correct tailing assays made, as the copper content is extremely low, the average for February being less than 0.05 per cent. Many have expressed doubt as to the correctness of this figure, which makes the recovery run between 97 and 99 per cent. However, the tailing samples have been checked by a well-known New York assaying firm, and in no case has a copper content of 0.077 per cent been exceeded.

Five men are employed in the mill on each shift, and usually two or three laborers loading concentrates on the day shift—one crusher man, one mill foreman, who handles the ball mill; one flotation man, one fitter, and one helper.

The complete milling cost for February was 96c. per ton of ore treated. This includes all charges from the time the ore is put on the grizzly until the concentrates are loaded on cars and ready for shipment to the Humboldt smelter. Royalty and trona constitute one-third of this cost. The trona is purchased in carload lots from Searles Lake, California, at the rate of $8.50 per ton, f.o.b. shipping point.

Water for mill and home uses is pumped from the Bill Williams River into three 230,000-gal. steel tanks, one of which is always kept full for protection against fire. Part of the water for the mill is also furnished by the mine.

A Radial Conveyor Belt for Distributing Ore in Bins

IN SMALL mills, the removal of the product from the rock breaker and its distribution in the mill ore bin are usually done by small steel ore cars running on a track placed over the bin. In larger mills, belt conveyors are more often used. The belt is placed on the long axis of the bin, and discharge is effected by a tripper, which may be shifted by hand, but is usually automatically controlled. The method of discharging the belt conveyor by placing a deflector at a given point to scrape the ore over the side of the belt is practically never seen, although it may serve as a temporary expedient. A radial type of conveyor is pictured herewith, Fig. 1 showing the receiving end and Fig. 2 the discharging end of the device, which is simple and effective. It consists of a short length of conveyor belt mounted upon a frame, one end of which is pivoted at a point near the rock-breaker discharge, the other end being mounted upon a two-wheel carriage running on a piece of curved track, the center of curvature being the pivot support of the frame. The method of use is obvious. This device is installed at the Mountain King mine, Mountain King, Cal.

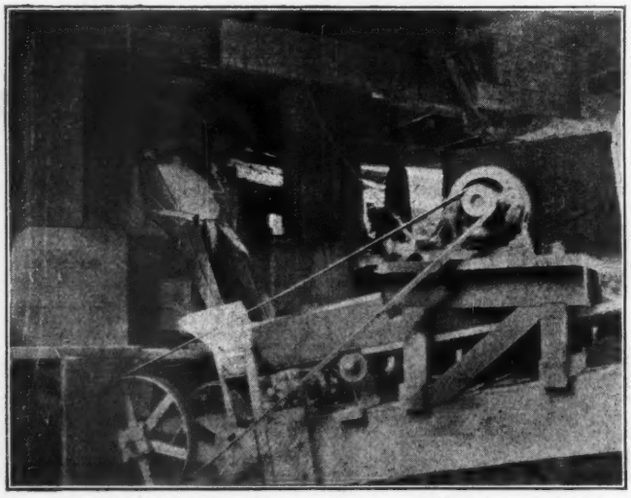


FIG. 1. RADIAL DISTRIBUTOR, RECEIVING END

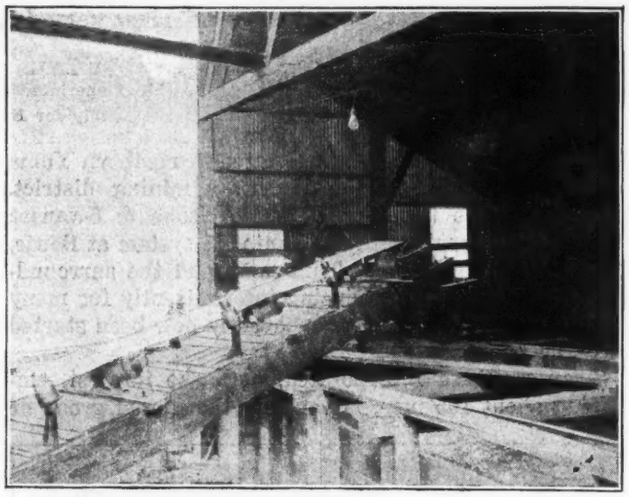


FIG. 2. DISCHARGE END OF RADIAL DISTRIBUTOR

Toluidin, A New Flotation Agent

Toluidin, as a flotation agent, is the subject of a patent recently issued to C. L. Perkins and assigned to the Metals Recovery Co. Mr. Perkins has been working along the lines followed by the late H. P. Corless, the use of toluidin being an application of the principles involved in utilizing alpha-napthylamine (X-cake) and xylidin. In his patent specification, Mr. Perkins describes the following experiment:

Five hundred parts of ore was ground in a pebble mill with 250 parts of water; sodium hydroxide equivalent to 2 lb. per ton of ore was added, and commercial mixed toluidin equivalent to 1 lb. per ton. The resulting pulp was placed in a Callow cell, with sufficient water to form a free-flowing pulp. The Utah ore treated contained about 1.42 per cent of copper. The concentrates produced contained about 15.4 per cent of copper, and the recovery of the copper was about 87 per cent. The use of alkali is not necessary in all cases, but it has been found greatly to improve the recovery.

The froth obtained is readily broken up, and the toluidin is recovered therefrom so that it is available for use in the treatment of further amounts of ore. The toluidin may be used alone to promote the flotation operation, and high grades of concentrates obtained; and the resulting concentrates can be much more easily separated by filtration than the common concentrates obtained by the use of oil. The action of the toluidin may, however, be modified or supplemented by adding other agents (such as oils or non-oleaginous agents).

In applying the toluidin, it may be introduced into the tube mill in which the ore is being ground, or introduced by dropping it into the ore pulp before it enters the flotation cell, or by first digesting it in hot water and mixing the product with the ore pulp.

Examination of Mill Returns

How To Keep an Accurate Check on Milling Operations in Small Plants—Sampling and Analyses—Practical Formulas for Determining the Relations Between Tonnage and Assays

BY DOUGLAS LAY

Written exclusively for *Engineering and Mining Journal*

THOSE who have had experience with the actual conduct of any kind of milling operations must have been confronted with the fact that, despite every apparent care, it is frequently found that the metallic contents of the tailings, plus that of the product made, do not agree with the contents of the feed, even when accuracy of the assays cannot be questioned.

The explanation may be a simple one, and clearly understood. On the other hand, more often than not the reason for the discrepancy is not obvious, and it is frequently customary, when a fairly long period is under review, for instance in monthly reports, to assume that the tailings sample is correct, and to adjust the feed sample on the basis of the tailings sample and the known values in the product made. The latter are not open to question, because, being marketed, weight and assay value are accurately known. Such procedure may save a good deal of worry, but it is open to serious criticism, inasmuch as, apart from any other reason, no real insight into what the mill is doing is gained thereby, and consequently no substantial increase in savings is likely to result from the continuance of this practice.

ANALYSES IN SMALL MILLS OFTEN DEFICIENT

In the smaller properties, analysis of mill returns is often rendered more difficult than in the case of large properties, because, owing to the ever-insistent call for economy during the installation stage, sampling appliances are frequently crude. Nevertheless, it is possible to do good work with fairly crude tools, and the purpose of this article is to tabulate those means whereby a close check may be kept on milling operations, even when a sampling mill is entirely absent.

WEIGHING FEED AND TAKING MOISTURE SAMPLES

It seems almost superfluous to state that *actual scaling* of every pound of ore treated is a matter of imperative necessity. Otherwise it is not possible to conduct milling operations with a high degree of intelligence. It is astonishing how often the weight is determined by estimation and to a large extent is a matter of guesswork. It is vital that the net dry weight of ore treated should be accurately known, otherwise any analysis of mill returns must rest upon an insecure basis, and inferences drawn therefrom may prove highly erroneous. Moisture samples of the feed should be taken frequently, and the gross weight shown by the scales should be corrected accordingly.

SAMPLING OF FEED

It is a common assumption that any discrepancies between contents of feed, on the one hand, and contents of tailings and product made, on the other, are due to incorrectness of feed sample rather than of the tailings sample, inasmuch as, in the absence of machine sampling, the sample of the comparatively coarse feed is not likely to be as accurate as that of the general tailings, which have been fairly finely crushed before sampling. On the other hand, common sense will support the view that, even if sampling methods are crude, there should be no plausible reason why samples should be persistently high or persistently low, and consequently the average of a *large* number of feed samples crudely taken should be "about right."

Furthermore, it is possible to demonstrate by the "Theory of Probability" that the average of a large number of samples, comparatively crudely taken, is likely to be far nearer the truth than is commonly supposed.

If

e = *the probable error of an individual sample,*

n = *the number of samples taken,*

D = *the probable departure from the truth of the average of n samples,*

Then by the formula of Gauss there is evolved:

$$D = \pm\ 0.6745\sqrt{\frac{\Sigma\,(e)^2}{n\,(n-1)}}$$

In the case of lead-zinc concentrators, the feed sample is usually taken from the feeder (after the feed has passed through a Blake crusher), feeding the coarse rolls, by inserting a scoop, say every half hour, and taking the contents of a stroke of the feeder, such individual samples being combined at the end of each twenty-four-hour period to form a day's sample for assay. In a month's run there will therefore be approximately thirty such samples. This is a common and incidentally a good method of sampling the feed.

Now, assume that sampling of the feed is performed in some such way as that stated, and that the daily sample is subject to an error of plus or minus 25 per cent. This is a much larger error than is likely to occur in practice. Then by the formula, in the course of a month, the probable error of the average of such daily samples is given by

$$D = \pm\ 0.6745\sqrt{\frac{30 \times (25)^2}{30 \times 29}}$$
$$= \pm\ 3.1 \text{ per cent}$$

and in the case of a year of, say, 300 working days

$$D = \pm\ 0.6745\sqrt{\frac{300 \times (25)^2}{300 \times 299}}$$
$$= \pm\ 0.97 \text{ per cent}$$

It is evident, therefore, that if a reasonable amount of care is exercised in sampling the feed, the average of a month's run will be close to the truth, and that in the course of a year (owing to the equalization of plus and minus errors) errors will have almost disappeared. It is obvious, of course, that the question of deliberate tampering with samples cannot be a factor for consideration in the foregoing. Incidentally, the "Theory of Probability" renders it evident that, in the case of a small property, at any rate, a sampling mill is hardly a business proposition, and is a matter of luxury rather than of necessity.

The arithmetic mean of the daily samples is frequently taken, disregardful of the fact that such may not be the true mean, owing to the tonnage treated varying from day to day. This is a common cause of apparent discrepancies. The assayer should be instructed to weigh out each day from the feed and tailings pulps amounts proportionate to the known net dry weight of tonnage treated. These samples are set aside until a month's run has accumulated, when they should be carefully assayed, checks being run to insure accuracy. Such samples truly represent the monthly average. Laborious arithmetical calculations will be entirely avoided thereby, and greater all-round accuracy will be insured, as they will be independent of any errors in daily assays. If desired, the same procedure can be adopted in the case of the products made, but in this case it is not likely to be so necessary, inasmuch as the products will be sold and weights and assays known with great accuracy.

FORMULAS

Formulas are frequently of great assistance in checking mill returns. It is often desirable, when tonnage of products is definitely known, to check assays, and, on the other hand, when assays are established, to check tonnages. At the same time the application of a rigid mathematical relationship between assays and tonnages should be leavened with common sense, and the maxim that "an ounce of fact is worth a ton of theory" should be kept well in mind. The greater the number of products and metallic values contained therein, the more complex will formulas be. The case is cited of a silver-lead-zinc feed yielding two products, lead and zinc concentrates, each containing metallic values in silver, lead, and zinc.

	Silver, oz.	Lead, per cent	Zinc, per cent
Let A = weight of feed assaying	a	b	c
B = weight of tails assaying	d	e	f
x = weight of lead concs. assaying	l	m	n
y = weight of zinc concs. assaying	o	p	q

Then $B = A - (x + y)$

Considering silver values, there results:

Silver in feed = silver in lead concs. + silver in zinc concs. + silver in tails.

$$\text{whence } x = \frac{A\,(a - d) - y\,(o - d)}{(1 - d)} \qquad (1)$$

Similarly considering lead values,

$$x = \frac{A\,(b - e) + y\,(e - p)}{(m - e)} \qquad (2)$$

Similarly considering zinc values:

$$y = \frac{A\,(c - f) + x\,(f - n)}{(q - f)} \qquad (3)$$

Combining (1) and (2) above and solving for y

$$y = \frac{A\,[(a - d)\,(m - e) - (b - e)\,(l - d)]}{(e - p)\,(l - d) + (o - d)\,(m - e)}$$

Combining (1) and (3) above and solving for x, the following equation results:

$$x = \frac{A\,[(a - d)\,(q - f) - (c - f)\,(o - d)]}{(l - d)\,(q - f) + (f - n)\,(o - d)}$$

It is of high importance that the total weight of tailings made by each individual concentrating device should be ascertained fairly frequently, in addition to the assays of such tailings. This in order that it may be definitely known what proportion of the total tailings is made by each. This is a matter of high importance when the question of a scheme for making closer savings comes under consideration. For example, in a lead-zinc concentrating mill it will be generally found that about 70 per cent of the entire weight of tailings will be contributed by three or four of the coarsest jigs, the remaining 30 per cent being yielded by the fine jigs, tables, and vanners. Furthermore, it will be found that the 70 per cent of coarse tailings will carry much lower values than the 30 per cent of fine tailings—not because the coarse jigs do the best work, but simply owing to the fact that they handle largely original feed, whereas the fine jigs and tables handle a feed enriched by the re-entry into the milling system of re-ground middling products.

In such cases it frequently happens that the fine end of the mill receives all the attention, when improvements are being considered, and the effect upon the tailings as a whole, caused by the installation of additional tables and slime-saving devices, is distinctly disappointing, the reason being that the great bulk of the tailings has been unaffected by the change. It must be manifest that unless the 70 per cent referred to can be re-ground and re-treated, there can be no substantial drop in the tailings as a whole.

Selective Flotation With Sulphur Dioxide

J. B. Parker, metallurgist for the Interstate-Callahan company of Wallace, Idaho, gave an informal talk on the Bradford selective flotation process at the University of Idaho School of Mines recently. He has had considerable success with the use of SO_2 on a small scale, the gas making the blende non-floatable and allowing the galena to be separated.

There is some question whether the SO_2 is best added intermittently in thickeners or other storage tanks, or can be used to better advantage in the flotation cell itself, provided the cell is of a type which will permit this readily. An interesting illustration was given by Mr. Parker of the effect, in the Interstate-Callahan mill, of burning sulphur in the vicinity of the zinc-flotation machine, the zinc froth being "killed" entirely for a considerable period, to the great mystification of the mill operators. The SO_2 in these experiments was produced in a special type of sulphur burner. The suggestion was made that the gas could be bought in cylinders and a much more careful control of the SO_2 concentration be thus secured.

Is Developing New Roller Bearing

A new type of bearing for ball or rod mills is being developed by David Cole, of El Paso, Tex. A 5 x 10-ft. rod mill so equipped carries 19 per cent of the load on a spherical trunnion bearing, 10-in. long, at the feed end; the balance is carried on ball-bearing rollers. A saving of 16 per cent of the power required with other mountings is claimed.

The Closed-Circuit Operation of Ball Mills in the Michigan copper country was recently initiated by the Quincy Mining Co. The installations are showing up very well indeed, but all of the refinements incident to the most perfect operation have not yet been made.

The Electrical Equipment of the Mill

Practical Advice on Its Selection, Installation, and Operation, With Particular Reference to Small Plants Where Expert Supervision Is Not Available—Things Every One Who Starts a Motor Should Know

BY B. B. BECKETT
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Written exclusively for *Engineering and Mining Journal*

THE following article is based upon experience gained chiefly at the Consolidated mill, of Goldfield, Nev., a 100-stamp cyanide mill treating gold quartz, but the statements may fairly be applied to similar mills generally throughout the western United States. As the three-phase alternating current system is used almost exclusively, this discussion will be confined to induction motors and synchronous motors. The latter are gaining in favor, but their use is confined to special cases. One advantage is that their power factor (ratio of useful to total current) is readily controlled, and they have several disadvantages. They require more expert handling in starting, and the starting torque is low. They require, also, direct current for excitation, entailing the use of a commutator machine, either built in or separately driven, with attendant commutator difficulties. They should be used only for large air compressors, large centrifugal pumps, and perhaps also for tube mills, provided the advantage of power-factor control justifies the added expense and complication. If tube mills are used, friction clutches will be necessary between the motor and the mills. This economic problem will have to be solved in accordance with conditions presented in any particular case.

Induction motors are of two kinds, constant speed (squirrel cage or cage wound) and variable speed (slip ring or wound rotor). Strictly speaking, all induction motors are constant-speed motors, as they tend to run at synchronous speed only and are inefficient at reduced speeds. The so-called variable-speed motor is therefore to be used only where high starting torque must be met, or for intermittent running, as in hoisting service. High starting torque is always desirable, but is obtained at the sacrifice of simplicity, entailing greater first cost and higher maintenance charges. The choice is therefore a problem, but, in general, the slip-ring motor is to be preferred to a combination of plain motor and friction clutch.

STANDARD EQUIPMENT MUCH TO BE PREFERRED

Standard stock motors should be used for all common milling operations, except that the more flimsy designs should be avoided. The service is rough as compared with that in some other industries, but the difference is not so great as to justify special design, with attendant difficulty in obtaining replacements and repair parts. For the same reason, all non-standard features should be avoided, such as special speeds, special shaft extensions, and special brackets on frames, unless these are clearly justified by other considerations. It is also desirable that as many motors be exactly alike as is consistent with good efficiency. That they be of the same make is not so important as that they be of the same speed and have the same size shaft extension, so that replacements and exchanges may be made quickly with a minimum number of spares on hand.

In regard to speed, the fact should be remembered that high-speed motors are not only cheaper, but are also usually more efficient, provided the drive can be made efficient. They also have the advantage of being easier to handle, on account of their lightness. No mechanical objection can be cited against the high speed so far as the motor itself is concerned, but considerations of drive fix certain limits, as given in Table I.

TABLE I. RECOMMENDED SPEED

Synchronous Revolutions per Minute; 60 Cycle Motors.

Rating	For Belting		For Gearing	
Hp.	Highest	Best	Highest	Best
1	1,800	1,800	1,200	900
2	1,800	1,800	1,200	900
5	1,800	1,200	900	900
7½	1,800	1,200	900	720
10	1,800	1,200	900	720
15	1,200	1,200	720	600
20	1,200	900	720	600
30	1,200	900	720	600
50	900	900	600	600
75	900	720	600	514
100	900	720	600	514
150	720	600	514	450
200	720	600	450	450

The table is based upon my experience, taking into consideration the quality of construction and the kind of operators usually found in mills. The recommended speed for gearing is much lower than for belting. This refers to plain spur gearing. If herring-bone gearing is employed, or if a flexible coupling is interposed between the motor and the first pinion, the speed recommended for belting should then be used, and the same is true for the silent chain drive. In general, plain spur gearing should be avoided except where the service is light or infrequent. Direct connection is the ideal drive, and should be used in all cases where the speed of the driven machine is suitable, except where it may be desired to change the speed readily. Even when the required speed is so low as to call for special motors, this is frequently justified by the advantages of direct drive, but each particular case of this sort must be solved independently. Direct connection does not mean merely coupling a motor to a drive shaft which is itself geared to the machine proper, as in a triplex pump. This would be a gear drive, and only low-speed motors should be used for this purpose, preferably through a flexible coupling. For true direct drive, like that of a centrifugal pump, the higher the speed the better, up to 1,800, and even 3,600 is satisfactory for small sizes, so far as the motor is concerned.

OVERSIZE MOTORS SHOULD BE INSTALLED ONLY IN SPECIAL CASES

In regard to size, it should be remembered tha the highest efficiency and highest power factor will be obtained if the motor is not much larger than required by the normal load; but this is not always practicable. Motors driving stamp batteries, tube mills, ball mills, air compressors, and pumps that run under constant conditions should all be quite close in size to the normal load. Motors driving crushers, elevators, conveyors,

rolls, Chilean mills, concentrating tables, roasters, and slime pumps should all be of a size two to three times that required by the normal load. In general, this last applies wherever the driven machine is likely to be choked by excessive or over-coarse feed, and wherever the friction element is large and variable.

The use of so many oversize motors will not greatly affect the load of the mill as a whole, as the great bulk of the load will always be in the first group, i.e., stamps, tube mills, and like devices. The power factor for a mill like that at Goldfield should be about 85 per cent. The power consumption will be close to 30 kw.-hr. per dry ton of ore milled, of which 20 kw.-hr. will be accounted for by the stamps, tube mills, and other grinding machines.

The standard induction motor starter (auto-starter or compensator) consists simply of a pair of small transformers mounted in the same case with a double-throw oil switch. A starter is generally rated on its name plate to correspond with the motor for which it is designed; but it may be used with any smaller motor just as well, and also with a larger motor if the starting duty is light. It does not need to be of the same make as the motor, as all starters are designed upon the same principle.

In modern starters, a number of special features have been incorporated. The first of these is the low-voltage release, now standard for all types. This device is required by the safety laws of some states, and should always be furnished, for the sake of interchangeability, even in the few cases where it is not desirable to use it. Advantage may be taken of the low-voltage release to rig up simple means of shutting down antomatically or from a distance, as it is merely necessary to open the circuit of the low-voltage coil to cause the starter to return to the off position.

Overload Devices Not Yet Perfect

Another special feature is the overload device, consisting of a pair of current relays, arranged to open the circuit of the low-voltage release whenever a certain current is exceeded. These relays may be instantaneous, like the ordinary circuit breaker, but are usually of the inverse time limit type. That is, each is equipped with a small bellows or dashpot, which retards its action in inverse proportion to the magnitude of the overload, the purpose being to prevent action under momentary overloads while permitting quick action under severe overloads. Although this idea is good, it has, unfortunately, not yet been worked out successfully; for it appears to be impossible to make a device at reasonable cost that will accomplish the desired result and remain in adjustment. However, the relays are to be recommended in all cases, as they do afford protection against short circuit and against sudden and severe overload, thus taking the place of fuses or circuit breaker. They should always be set high, 50 to 100 per cent above normal load, to avoid the nuisance of shutting down unnecessarily. A satisfactory overload relay is being developed, and it is to be hoped that real overload protection will soon be obtainable.

Another modern addition to starters is the ammeter, a desirable feature for all large motors, say 50 hp. and up. The operators will soon become accustomed to a normal position of the ammeter pointer and readily note any change, indicating probable trouble, without waiting for the motor to begin to smoke. It also serves to show, in starting, when the motor is up to speed. A common fault is to throw over to running too quickly, and the ammeter is the best way to tell when the right time comes. For this purpose, the ammeter should be in circuit all the time and have a scale reading up to about four times the rated motor current.

Starters Advisable on Practically All Motors

Starters are not usually provided with motors of 5 hp. and under; but they may be desirable down to 1 or 2 hp., to reduce the jerk that always accompanies starting direct on the lines; and they may be omitted with much larger sizes if the starting jerk is permissible and if the line will stand the current rush (five to ten times normal) without too much voltage disturbance. However, there is not much saving in omitting starters with large motors, as an oil switch must be provided instead, large enough to handle the heavy current.

When no starter is used, the switch which takes its place should be of one of the modern "safety first" designs. It should be inclosed to prevent accidental contact, should be either an oil switch or provided with barriers to prevent flash-over, and should be of quick-make-and-break design. It should be equipped with low voltage release, unless the conditions are clearly such that no danger can result from unexpected starting after an interruption of power. For overload protection, simple fuses are sufficient, and even these may be omitted if the line has the usual protection at the branch point. For the motor, fuses, however, are of little use unless they have a long time limit, for otherwise they will have to be of a size 50 to 100 per cent above normal load current. Some form of time-limit fuse or fusible link having a large heat-storage capacity is much to be preferred for this service.

For variable-speed motors used in hoisting or similar service the simple drum controller is satisfactory up to about 50 hp. Above this, if the service is frequent, contactors should be used in the primary at least, and above 100 hp., full contactor control with automatic notching up should be used. The liquid rheostat, because of maintenance difficulty, is not to be recommended except for large hoist motors.

Push-button control is meeting with favor, and is to be recommended, both as a safety and a labor-saving device. The increased complexity is offset largely by a saving in maintenance resulting from more perfect action. This matter, as well as the various applications of automatic remote control, must be specially solved for any particular case.

A simple open-knife switch should immediately precede each starter or controller, to serve as a disconnect switch for the use of the electrician in working on the starter.

The push-and-pull type of handle is generally preferred by operators to the right-and-left swing style or the horizontal revolving style.

Wiring Must Be Carefully Installed

The best method of wiring, if properly done, is in a rigid iron conduit; but open wiring is better than conduit wiring improperly done. In general, services and small branches should be in conduit; but for mains, where they can be run overhead in the clear, the advantage is too small to justify the expense. Metal service boxes should be provided to house the disconnect switch at each branch, and at each starter or con-

troller; and the wiring between service box, starter, and motor should be completely in conduit.

When the installation is large, requiring heavy copper in the mains, these should be broken up into several circuits, and should be grouped by circuits and not by phases, in order to avoid excessive inductive reactance.

Transformers should be installed just outside of the main building and near the head of the mill, as the bulk of the load is always at the head. Open-air transformer installation is generally to be preferred. Transformers should be of ample size to take care of any probable future increase in load, as the loss of efficiency due to using oversize transformers, if of modern design, is very small. A spare transformer is not usually justified, as the risk of failure is small. This applies also to the use of trucks permanently installed under transformers and to other devices for quick handling in emergency.

The question of voltage is one to be solved for the individual case, but in general it is better to stick to one standard for all motors, large and small, and to select that standard that is most common in the district, so as to facilitate exchanges, replacements, and repair parts. This voltage is usually 440 in the western United States. Where power is purchased at a primary voltage of 2,300, it will usually be advisable to use this voltage on all large motors, and 440 on the smaller sizes, e.g. 40 hp. and under.

Failures are naturally more common in motors than in other parts of the electrical equipment, and are usually due to some mechanical cause, frequently outside the motor. Attention to drive conditions will save the majority of motor troubles.

Keep Bearing Oil Out of Motor Windings

At the Consolidated mill in Goldfield sixty-five motors were installed, and failures averaged about two per month, but only about one-fourth of these were burn-outs requiring re-wiring. Most of these motors were old and had been repaired several times, so that failures were to be expected. By far the most fruitful cause of motor failure was bearing trouble, either directly or indirectly. Despite a regular system of inspection and gaging, bearings would frequently go out, permitting rotor to rub stator. This is the worst thing that can happen to a motor, as it damages the laminations as well as the coils, and can be completely repaired only by the installation of a new core. Indirectly, bearings may cause insulation failure by leaking oil. This is often difficult to overcome, although it may be reduced easily to an amount that will not constitute a menace to the bearing itself. One drop a day will eventually saturate the winding, dissolve the insulating varnishes, raise the temperature by collecting a coating of dust, or permit movement of the coils in the slots until the insulation is worn through from constant rubbing. Another evil of oil on windings is that it permits water to enter, strange as it may seem; and when an oil-soaked winding has been wet, it is much more difficult to dry out than if the oil were not there. The only way to really remove the oil is by re-winding, but a fairly satisfactory way was developed at Goldfield as follows: The winding was first cleaned by hand and compressed air; then by a spray of gasoline applied with compressed air; then dipped or brushed with baking varnish; and finally baked.

The most common cause for leaking oil is vibration. The whipping about of a journal in its bearing, and sometimes of a bearing in its housing, splatters the oil out in a fine spray, which collects on the shaft and thence crawls into the spider, or collects on the inner lip of the housing until a drop is drawn, by suction of air, into the winding. Another cause is too much oil. The practice in most mills is to oil motors frequently and without care except to see that there is enough. This practice is bad. If a motor is properly installed, it will run for months without oiling, and if it does leak so that oil must be added, this should be put in through the oil gage, not the bearing cover. The cover should not be raised except for inspection, and then only with the greatest care to prevent dust falling inside. Modern motor bearings are much better designed from the standpoint of leaking oil than were some of the older forms.

Vibration, besides its effect on oil, is itself a common direct cause of motor failure. It causes connections to break loose, rotor bars to break in two, and even frames to break. The most destructive kind of vibration is not a shake that can be seen, but a fine, sharp buzz that can be best detected with the finger nails. Such vibration is produced by gearing at high speed and poorly meshed, or by mechanical unbalance in rotor or pulley. The resulting phenomena come under the head of what is commonly called crystallization. Vibration is also a frequent cause of destructive sparking at commutators and slip rings.

Proper Care and Operation of the Starter

Starter failures, although almost as frequent as motor failures, are usually of minor consequence. They are almost always to be found in the contacts, which are, of course, subject to regular wear and replacement. The electrician can save many trouble calls by observing a regular system of inspection of contacts. This involves shut-downs, and the time lost may be as great as would result from the system of waiting for the trouble calls, but it is not so annoying or destructive to morale. There is always a danger, too, from allowing contacts to go until they fail, for a motor may be injured by running on single-phase, due to the failure of one of the running contacts. On the other hand, the wear on contacts may be greatly reduced by more careful handling on the part of operators. As a rule, operators have no idea what is happening inside a starter, and a little instruction will be beneficial in this particular:

Always throw the starter handle quickly and hard. Never "tip" the contacts on and off several times with the idea of an easy start. This does not result in an easy start, but produces a series of jerks, and the contacts are burned at each "tip" many times as much as for the whole operation of starting when properly done.

Always wait until the motor is up to full speed before throwing over to the running position. The current to be carried, and consequently the amount of burning at the contacts, is almost as much nearly up to full speed as at the start; it then drops rapidly, as synchronous speed is approached, until, without load, it finally becomes steady at one-fourth full load value. This is the time for the throw-over. It is evident, therefore, that an ammeter will assist greatly in determining the proper time. No other way is sure except to be careful to wait long enough. No harm will result from overdoing it provided the motor has really come up to speed within the proper time.

If the motor does not start, or does not come up to speed in about one minute, the starter must be thrown off, else both it and motor may be overheated. It is then necessary to wait fifteen minutes or more for the starter and motor to cool off before making another trial. Never make several trials in quick succession unless you have meanwhile thrown off considerable load, as, for instance, by opening a friction clutch.

Starters equipped with quick-make-and-break handles are to be preferred to the plain-handle type.

The practice obtained at Goldfield, and should always be observed in a mill of that size, for the electrician to follow a regular routine system of inspection. He should go through the mill every morning, except when on a trouble call, inspecting all motors superficially; and about twice a month he should examine each motor and starter while shut down. He should also examine all contacts of knife switches and fuses, to see that none is running hot. Transformers should be inspected at least once a year, particularly the oil used, to see that it is of good color and that it is at the proper level, that is, well over all internal connections. The same is true, also, for high-voltage oil switches. Low oil is responsible for most of the failures of transformers. The electrician should not delegate this inspection duty to a mere helper. Its importance should be measured by the rule that "An ounce of prevention is worth a pound of cure."

In regard to the kind of oil for use in motors, common engine oil is entirely satisfactory. It is far more important carefully to exclude dust and dirt than to use high-grade oil. For the larger sizes, a heavier grade of oil is often advisable, particularly for bearings that have a tendency to throw out the oil. This may be obtained by simply adding cylinder oil or other heavy oil to the standard grade. On the other hand, the best obtainable grade of bearing metal is usually warranted for renewing bearing linings.

Water Economy in Mills

Saving Small Amount Sometimes Very Necessary in The Dry Season—Some Ways That It May Be Accomplished

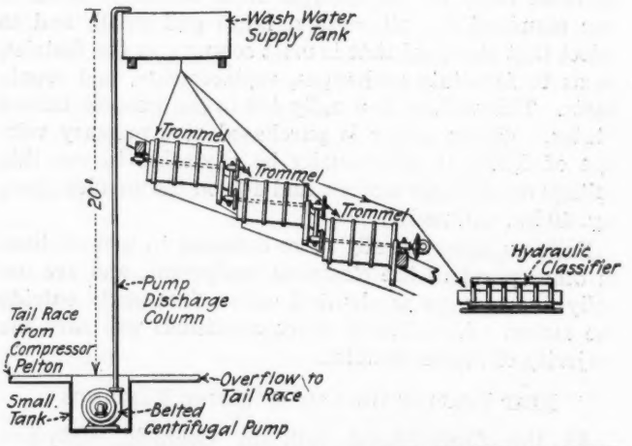
BY DOUGLAS LAY

Written exclusively for *Engineering and Mining Journal*

IN THE case of mills operated by water power it is frequently necessary to save every drop during the low-water season. As the latter approaches, many uses which are permissible when water is abundant must be discontinued. It is astonishing how the saving of a trivial amount of water will restore the balance of power and render an undiminished output possible. The saying, "A little more, and how much it is; a little less, and what worlds away," applies, to the letter, to water-power installations.

Obviously, the speed of the machinery must be maintained, or the efficiency of concentrating devices will fall off to the vanishing point. Economy must be directed at securing maximum speed with minimum power consumption. Much may be done by reducing the size of the Pelton wheel nozzles, as the low-water season approaches. To get the maximum efficiency out of a Pelton wheel, it must be run with the gate valve wide open. The loss of efficiency which is caused by partially closing the gate valve is frequently not understood. Several interchangeable nozzle tips should be at hand for each wheel. The variation of a sixteenth of an inch in the diameter of the nozzle tip, especially in the case of the larger nozzles, may make a material difference in operation. Close calculations as to power possibilities should be made. It is a simple matter to babbitt a nozzle tip so that its size is correct to the sixteenth of an inch. Incidentally, this is far cheaper than having one specially made for the purpose.

Divide the power into as many units as practicable, so that variations in power consumed by any one machine shall not have the effect of varying the speed of others. For example, to run a Blake crusher and jigs off the same shaft would be bad practice. In the case of a small mill concentrating, say, lead-zinc ores, three Pelton wheels give an efficient arrangement, one operating the battery of tables, another the Blake crushers, and a third driving the remaining machinery.



SAVING POWER BY PUMPING WASTE WATER, RATHER THAN USING HIGH-PRESSURE WATER

Most mills are, or should be, so designed that the tailraces from Pelton wheels can be used for wash-water purposes. Even so, the trommels and hydraulic classifiers, being necessarily placed at the top of the mill, usually have to draw on the power water for their supply of wash water. If power water is used direct for the purpose, this is extremely wasteful, inasmuch as high heads are the rule, and every cubic foot of power water may represent close to one horsepower. A high degree of economy is obtained by utilizing the power water indirectly to supply wash water; that is to say, by devoting 2 or 3 hp. to a centrifugal pump, a volume of wash water may be raised to the trommels and other machines equal to many times the volume of power water consumed in the process.

To cite a concrete case: At a mill which I operated, discharges from all Peltons were about 20 ft. below the point at which it was necessary to supply approximately 25 cu.ft. of wash water per minute. A centrifugal pump, consuming approximately 3 hp., or 3 cu.ft. of power water, per minute in this particular case, raised the required wash water from the tailrace of a Pelton operating a compressor. Had the high-pressure water been used direct, 25 hp. would have been absorbed. The installation of the pump illustrated in the accompanying sketch, therefore, resulted in a saving of 22 hp. The pump, centrifugal or other kind, should be set so that the water supply flows into it; the pump is thus always primed.

Thickeners and Decanting Appliances

Two Principal Types in Use Today Are Represented by American and South African Practice —Several Minor Improvements Made in Continuous Thickeners—Bowl Classifiers of Advantage in Certain Work

BY HENRY HANSON
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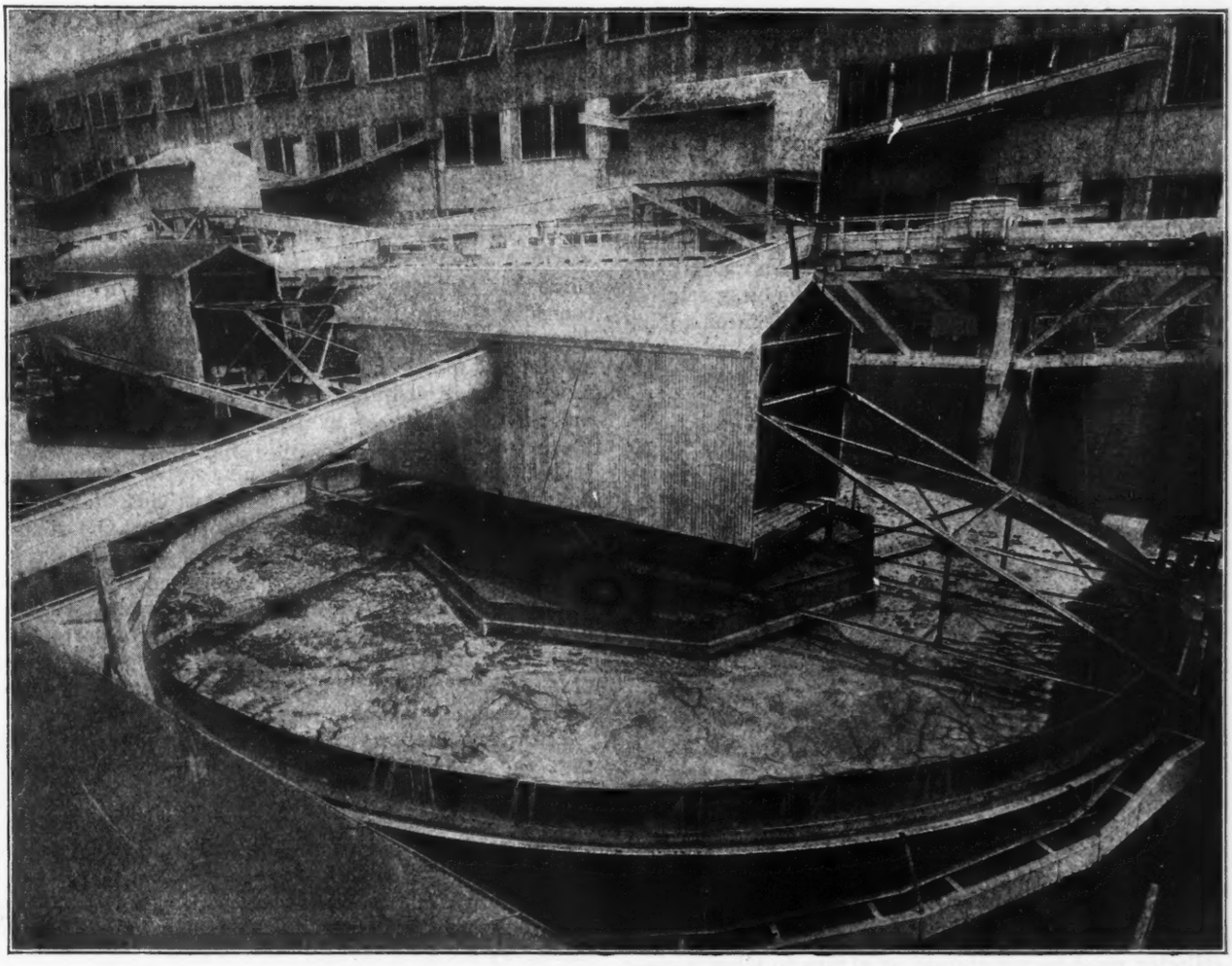
Written exclusively for *Engineering and Mining Journal*

WITH the successful application of flotation to base-metal ores, the field for thickeners has been greatly enlarged, because of the vital importance of providing an efficient means of dewatering the flotation concentrates. The recent development of industrial chemistry has further increased the usefulness of such machines. As a result, the mechanical thickener, developed principally in cyanide plants, has found instant and successful application in these large-scale operations. Although the new fields have added greatly to the uses of machinery of this type, this article will be confined to thickeners and decanting appliances as applied to precious-metal mining.

Development of the most successful devices for the purpose has been largely along two lines. The first can be termed the intermittent or non-mechanical thickener, which has found its greatest application on the Rand; the second type may be designated as the mechanical or continuous-discharge thickener, the type which has come into almost universal use on the American continent.

Inasmuch as many millmen are not familiar with South African cyanide practice, it is well to summarize briefly the Rand method of treating slime. Crushing is by stamps, followed by tube milling. The plate tailings are classified into sand and slime. The slime, representing about 40 per cent of the ore, carries over 70 per cent of the water used in the stamps. This thin pulp is run into collector or thickener tanks, at such a rate as to insure a clear overflow, until sufficient solids have been deposited to make up a charge. When the charging of the collector is completed, the clear water is drained off by a decanter lowered below the level of the overflow.



DEWATERING FLOTATION CONCENTRATES AT INSPIRATION

After the slime has been allowed to settle to its greatest density, and as much water as possible has been removed, the pulp is transferred from the collector to the first wash tank. In this transfer the thickened pulp is diluted with gold-free cyanide solution. The transfer is effected by a pump, and during this period of filling the first wash tank, the pulp is kept in agitation by a circulating pump drawing the pulp from the bottom of the slightly conical tank and returning it to the top. The ratio of the solution to solids in this first transfer tank after dilution is usually about four to one.

After the transfer from the collector to the first wash tank is completed, the pulp is allowed to settle; the excess solution is decanted off, clarified and precipitated; and the thickened slime is transferred into a second wash tank, where barren solution is again added. The pulp, during this second transfer, is agitated by a pump, as in the previous operation. Two washers with suitable volumetric dilution are usually sufficient for the maximum economic extraction. In this system the dissolution of the values in the slime is accomplished in transferring the pulp from the collector to the first and the second wash thickeners, instead of using agitators, as is the American practice. The soluble metals are removed from the slime by the simple method of dilution and settling in thickeners.

The apparatus required for this decanting and thickening operation is simple, consisting of pumps for transferring the thickened slime from one tank to another. The so-called decanter is attached to the tank at a point low enough to allow it to drain off all the clear solution when tilted over to a nearly horizontal position. This is accomplished by having a pipe flange bolted to the walls of the tank at a point somewhat below the slime level when a charge is settled to its maximum density. To this flange a short nipple is fastened, to which is attached a 90-deg. ell. This latter fitting is followed by another short nipple and a 90-deg. ell. A pipe, or a decanter, is screwed to this second ell. The length of this pipe is such as to allow the end to reach a point near the center of the thickener when lowered to a point where no further clear solution can be drawn off from the thickened pulp.

The intake at the end of the pipe is protected by a screen to prevent foreign matter from entering. The decanter is submerged only slightly below the surface of the liquid, so as not to create unnecessary disturbance to the pulp below the level of the intake. The feed to the collectors is laundered to the center of the tank and discharges into a sump extending down into the tank several feet below the level of the overflow, so as to prevent disturbing the clear overflow during the charging of the collector. The sump is supported from a bridge above the tank.[1]

From the above, it is apparent that the feed to the collector must be maintained at a rate to allow a clear overflow, or the feed to the tank must be delivered intermittently, as the ratio of solids to water is about one to ten.

To facilitate the transfer of the thickened slime from one tank to another, the thickeners are provided with slightly conical bottoms. The transfer pump intake is at the apex of the cone, and the thickened pulp is diluted to its proper consistency by barren solution delivered through a nozzle into the intake of the pump suction, the amount of solution being controlled by a valve easily accessible to the operator. Barren solution is also added from the top of the tank through a nozzle discharge that can be brought to play on any part of the tank to wash down the thickened slime to the suction intake at the apex of the cone.

[1]W. R. Dowling, "Rand Metallurgical Practice," Vol. I.

American Thickener Practice Different

A thickener introduced at the Homestake mine by Mr. Merrill was a noticeable modification of the Rand practice. Flat-bottomed tanks were provided with 45-deg. inside wooden cones. The tanks were also provided with inside wooden launders that could be leveled by planing down the leveling strips to insure an even overflow. A sump was placed in the center of the tank to which the feed was delivered, as in the South African practice, but in this case the function of the thickeners was only that of dewatering. The rate of feed to each tank was such as to insure a clear overflow.

The slime, settled to the required consistency, was drawn off from the center of the tank at the apex of the cone and was conveyed by a pipe into a launder at one side of the tank, the point of discharge being at an elevation near the top of the inside wooden cone. When several tanks were placed in a row, this scheme of raising the discharge to a point near the middle of the thickener had certain advantages, as it was possible to give ample grade to the launder carrying off the thickened slime and at the same time keep the launders well above the bottom of the tanks. The feed and discharge was continuous, and the consistency of the thickened slime was controlled by a unique local invention which consisted of a special plug valve, a nozzle, and a bushing. The plug valve was provided with lugs, and the nozzle, having a tapered bore, was fitted with a removable case-hardened bushing. The bore of the bushing was made in different sizes, in order to control the amount of the flow as well as the density. As the nozzle had slots that engaged the lugs on the plug valve, a change of bushings could be effected in a few seconds. The function of the bushings is not only to control the volume and the consistency of the pulp discharge but also to take up the wear, as, with the plug valves kept wide open, as they are, practically all the wear comes on the bushings. When the aperture becomes too large, the bushing is transferred to tanks requiring one of larger bore, or is discarded. The cost of replacement is light, as the bushings are only rough castings.

Each tank discharges into a small sump overflowing into the launder which carries the thickened pulp away. The object of delivering the thickened slime to a sump is to prevent spattering and also to obviate the cutting action of the nozzle discharging direct into the launder.

By maintaining a reasonably uniform feed to the thickeners, and by removing chips and other foreign matter by a coarse screen, the thickeners require little attention.

When designing the cyanide plant for the Empire mine, at Grass Valley, I specified this type of thickener, and most satisfactory results were obtained. Present-day practice, however, imposes certain practical limitation to the use of this type of machine. The most important of the several objections is that it is impossible to discharge a pulp of as high a specific gravity as can be obtained in the mechanical thickener; moreover, a tank of much greater depth is also required than is necessary when using the Dorr apparatus.

In the summer of 1907, J. V. N. Dorr, then operating

the Mogul plant, near Deadwood, S. D., showed me a drawing of his continuous-discharge thickener. It was of the mechanically operated single-deck type, and I confess that at the time I was not particularly impressed with the future possibility of the machine, nor was I quite sure that certain vital mechanical defects would not develop when the thickener was put into actual service. In fact, I was of the opinion that any interruption in its operation such as would be occasioned by power failure or other causes might result in bending the arms when the machine was again started, or in breaking the spider or hub casting to which the scraper arms are attached. Moreover, at the time, I was em-

TWO HUNDRED-FOOT DORR THICKENER DEWATERING FLOTATION TAILINGS AT THE PLANT OF THE INSPIRATION COPPER CO., MIAMI, ARIZ.

ployed in the cyanide department of the Homestake, where there had been developed the continuous discharge thickener already described, making use of no mechanical apparatus in its operation. This fact no doubt served to dampen any enthusiasm that I might otherwise have been inclined to show on hearing of the Dorr machine.

Today the Dorr thickener is the one that is most often seen in America, and although a number of trimmings have been added during the twelve years of its development and successful operation, it has nevertheless experienced no change of importance in its main features. The inside launder, the worm and worm-gear drive, the vertical shaft with the sliding key, the truss for supporting the gear wheel, the scrapers on the arms, the brace rods between the arms, and the rods for adjusting the angle of the arms are all features, as I remember, that were included in the original drawing. But in this machine, as in most new devices, with the broadening field of application several improvements have been made. Probably the most important of these is the addition of one or more trays, thereby greatly increasing the settling capacity of the tank on the basis of the surface area occupied.

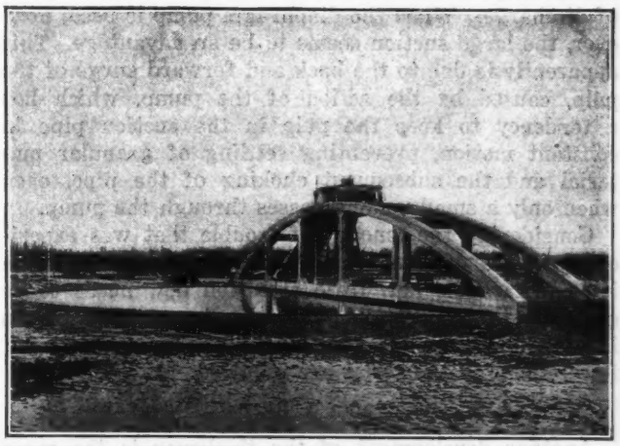
The mechanical parts have been so enlarged and strengthened as to make possible tanks of very large dimensions. The 200-ft. thickener now in operation at the Inspiration Copper Co. plant makes the 20- and 24-ft. tanks, once considered more or less of a standard, look very modest. The tanks are built of wood, steel, or concrete, depending upon which material is most suitable for the product to be handled, as well as the most economical.

Such refinements as the steel yoke for lifting the arms and the electric bell for sounding the distress signal or overload were, I believe, developments made in operating plants in the Porcupine district. At any rate, the old method of relieving the thickener when in distress was to lift the vertical shaft to which the arms are attached, by means of a chain block. Suitable anchorage above the thickener to which the chain blocks could be fastened was not always available. When starting the Dome mill, trouble of this kind was experienced.

To overcome the difficulty I made up a wooden yoke consisting of two legs, 24 in. long, and a cap of approximately the same length spiked to the top of the two legs. In the center of the cap a 1-in. hole was bored, which allowed the threaded end of an I-bolt of suitable size and length to pass. The wooden yoke, built of 8 x 8-in. timber, was placed with the legs on the hub of the gear wheel in such a position that the I-bolt engaging the swivel on the end of the thickener shaft would pass vertically through the cap in the yoke. Thus, by the use of a heavy cast-iron washer, a nut and a monkey wrench, the shaft and the thickener arms could be lifted either when in motion or when at rest, by the effort of a single man.

The Dorr company is now providing each thickener with a steel yoke and an I-bolt of the necessary strength to raise the shaft. An electric bell is now connected up to the mechanism to give warning that the thickener is being operated under too heavy a load. Before this electric bell was installed, I found it advisable to keep the belt used to transmit power from the counter or lineshaft to the thickener sufficiently slack to allow it to slip or come off rather than run chances of overloading the thickener to the breaking point.

Spare parts, such as worms or worm gears, are usually kept in stock for emergencies. Although these parts sometimes break, I have never had to replace any



NINETY-FOOT DORR THICKENER, SHOWING CONCRETE SUPERSTRUCTURE

of them, but, in my experience, several of the cast-iron hubs to which the arms are attached have broken, and being without the necessary renewals, I have, on two occasions, repaired a broken hub by making use of an inch rod, threaded at both ends, and made into a U-bolt of the necessary size to clamp the two parts of the hub together and thus hold the spider in proper position on the thickener shaft.

In plants reducing precious-metal ores, the counter-current decantation system has been introduced extensively, and differs in no way from the old method as to the actual functions of thickening. In the counter-current scheme, however, the thickeners are in series, the thick-

ened pulp passing from the first tank to the second, and so on until the last is reached, while the barren or diluting solution passes from the last in the series to the first, counter current to the flow of the thickened pulp. The thickened slime is passed from one tank to another by diaphragm pumps placed on a platform near the top of the tank. The suction of the pump is connected to the small cone at the bottom of the thickener. The elevation to which the pulp is raised by the pump is such as to allow a gravity flow to the center of the top of the next thickener in the series, each tank in the series of pulp flow being a little higher than the preceding one, so as to make possible a gravity solution flow to all tanks in the series. A difference of 24 to 30 in. in elevation is sufficient for this purpose.

In counter-current decantation it became very important to develop a satisfactory apparatus to transfer the pulp from one tank to another. Several different schemes were tried out. Air lifts were unsatisfactory, as it was impossible properly to control the flow. Diaphragm pumps were, for a time, a source of much difficulty to the operator, but after many improvements a pump of this type has been developed and perfected to a point where it gives little or no trouble. The length of the stroke can be adjusted so as to give perfect control of the volume of pulp handled. Even after a shut-down of considerable duration the pump can be started by introducing solution at a point near the suction intake, thus clearing the pipe.

My experience has been that, when drawing thickened slime direct from a thickener through a large pipe bushed down at the end, the slime will choke off, owing to the slow movement of the flow in the pipe. In fact, I have on several occasions found it advantageous to replace a 4-in. pipe by a 1½-in. pipe, in order to increase the velocity of the flow from the thickener to the point of discharge. When the diaphragm pump is used, however, the large suction seems to be an advantage. This apparently is due to the back and forward surge of the pulp, caused by the action of the pump, which has a tendency to keep the pulp in the suction pipe in constant motion, preventing settling of granular material and the subsequent choking of the pipe, even when only a small volume passes through the pump.

Considering the amount of trouble that was experienced in transferring the thickened pulp at one time, it is remarkable how little attention now needs to be given to this operation. The counter-current system is sometimes supplemented with filters, in which event fewer tanks in the series are required.

The Bowl Classifier a Recent Development

Another development of the thickener is the more recent but well-known Dorr bowl classifier. This machine combines the thickening features of the Dorr thickener, the upward washing current of the hydraulic cone, and the forward raking action of the Dorr classifier. The combination of these features has a decided advantage for certain work over the classifier alone. Not only is the overflow area much greater than in the classifier, but the surface disturbance, due to the wave action created by the moving rakes, is eliminated, making it possible to obtain an overflow carrying no coarse material at all. The sand being raked forward in the classifier is washed free of material already sufficiently fine to require no further re-grinding by the upward current meeting the settling pulp.

From what has been said it is apparent that the American and South African thickener practice has developed along two different lines, the American cyanide practice having tended more to all-sliming. That no standard practice has been applied to both the Rand and the American ores is not strange. The ores on the Rand are strikingly similar, but the ores on this continent vary widely, and require much more elastic equipment. The labor and the climatic conditions are also vastly different in the two cases.

Other Devices Are Obsolescent

Many other types of thickening devices, such as the spitzkasten or V box, and the cones, have been used, but I believe that the two systems already described are the only thickening methods that survive in full vigor today. This statement may possibly soon need revision, as the Genter thickening device is now being introduced. The principle of the Genter thickener is like that of the filter; the leaves are submerged in the pulp, and vacuum or pressure is used to deposit the solids and automatically and periodically to kick off the cake.

Alfred James, the English metallurgist, in his recent annual letter on cyanide practice, takes occasion to criticize American methods. The thickener, the agitator, and the filter each comes in for its share of criticism. The American practice no doubt may still be improved, but the adoption of Rand methods to American conditions would certainly not better matters in any way, for even in such plants as the Homestake, where separate treatment of sand and slime is practiced, the adoption of South African practice would not only be impracticable as far as the slime treatment goes, but would also result in economies on the wrong side of the ledger.

Differential Flotation in the Coeur d'Alenes

Satisfactory differential flotation of zinc-lead ores of the Coeur d'Alenes can be made, provided the minerals are not too intimately mixed. Such separations show recoveries upward of 80 per cent, with lead products assaying 60 per cent lead and 6 to 8 per cent zinc, and zinc products carrying 40 to 45 per cent zinc and 5 to 6 per cent lead. Mixtures of No. 2 or No. 4 Barrett oils with coal-tar creosote in sodium silicate or carbonate solution generally give good results.

Power Required for Flotation

Walter Broadbridge publishes a brief table in the March issue of the "Bulletin of the Institution of Mining and Metallurgy," giving the estimated horsepower required for flotation plants of various capacities. Ten to eighteen, he says, is required for plants treating from 50 to 150 tons of crude ore per twenty-four hours; 25 to 50 hp., for 150 to 400 tons; and 70 to 130 hp., for 600- to 1,000-ton units. At Anaconda, the power figure is given as 0.213 hp. per ton, and at Inspiration, 0.176 hp. per ton. The former uses Minerals Separation machines and the latter, cells of the Callow type.

The Peripheral Speed of Ball Mills should vary inversely as the fineness of grinding; from 375 to 400 ft. per minute for minus 48-mesh product and 550 to 625 ft. per minute for coarse grinding, say 8-mesh. This was one of the points brought out at the recent flotation conference at Moscow, Idaho.

The Water Supply of the Nevada Consolidated

Surrounding Mountain Springs Utilized—Reservoirs and Feeders Constructed—Redwood Found Preferable to Douglas Fir for Pipe Lines—Churn-Drill Holes in the Valley Proved of Little Value.

BY LINDSAY DUNCAN

Written exclusively for *Engineering and Mining Journal*

COPPER concentration is essentially a manufacturing process, in which it is necessary that ore, power, and water be continuously delivered to the mill while concentrates and tailings are continuously removed. Under the modern practice of electric drive, the power plant may be placed wherever convenient. The ore is invariably a matter of railroad haul, either above or below ground, and the water, of which from five to eight tons are required per ton of ore, must be piped and frequently elevated.

In deciding on a location for the Nevada Consolidated mill, the engineers were fortunate in being able to select a site to which most of the water flowed by gravity, with an ample area available for tailing disposal, also by gravity, and with descending grades for ore haulage.

The water for the Nevada Consolidated mines comes from a series of springs high up on the western slope of Ward Mountain, and is brought to a distributing reservoir through an 8-in. slip-joint steel pipe seven miles long. The flow ranges from 40 to 120 gal. per minute and is measured by a Venturi meter set in the line near its point of discharge.

The springs are scattered along the hillside for a mile or two miles, and, to obtain the maximum flow, a short tunnel was driven under each spring, cutting the flow before it reached the surface. A cement-lined sump with a blow-off and a pipe connection directly into the main completed the installation. The entrance of each tunnel was boarded up to exclude animals and prevent pollution of the supply. This method insures the maximum continuous flow, free from interruptions due to ice, snow, or rock-slides.

The gravity supply for the mill and smelter at McGill comes from Duck Creek valley, which contains 100 square miles and lies immediately beyond the range of hills east of McGill. This valley is bounded on the west by the Shell Creek range, which is between 9,000 and 11,000 ft. high, and on the east by the Duck Creek range, which is about 8,000 ft. high. The ranges combine at the north and south ends of the valley, which is about twenty-three miles long and from four to six miles wide. About eighty-five square miles of this watershed is available, all of which lies above 6,700 ft. elevation.

It became evident at an early stage of the mine and mill development that it would be necessary to develop the Duck Creek water supply to the utmost. A topographical survey was made of the watershed early in 1907, and weirs were installed on the various streams at critical points. The main intake was placed 105 ft. above the discharge end of the main line, and a small diverting dam was built at this point.

The main line consists of 36,000 ft. of 32-in. wood-stave pipe, and 10,000 ft. of 32-in. riveted-steel pipe, one-half of which is of No. 10 gage and one-half of No. 12 gage plate. This steel-pipe construction was necessitated by the precipitous sides of the canyon where Duck Creek breaks through into the Steptoe Valley, compelling the location of this portion of the line 150 to 200 ft. below the hydraulic gradient. The construction of this line was begun in September, 1907, and water was turned through it in December of the same year.

The wood-stave line was built of Douglas fir and banded proportionately to the pressures in various sections. Air-relief valves were placed at all high spots on the line, and blow-offs at the low spots. This line has a capacity of between 20 and 21 sec.-ft., depending upon the head available at the intake. The inlet is at an elevation of 6,670 ft., and discharge is at 6,565 ft. A back pressure is maintained sufficient to keep the hydraulic grade above the pipe line. This back pressure varies from 5 to 20 lb., depending upon the flow through the pipe. The resulting pressure is utilized to force water to the top of the ore trestle for locomotive use, for fire protection at that part of the plant, and, after filtering, for domestic purposes in the McGill townsite.

With the exceptions noted above, the entire flow of the Duck Creek line passes into a screening tank, and then, by means of an inverted siphon, through the power-house condensers and to the mill. At the lowest part of the siphon is connected the discharge pipe from the pumping station at the McGill Springs.

WOOD-STAVE PIPE OF DOUGLAS FIR NOT ALTOGETHER SUCCESSFUL

The wood-stave pipe line is laid on sills at 3-ft. intervals and banded with ½-in. round steel bands, which were dipped in asphaltum before being applied. The line has required considerable care and attention because of rotting at the ends of the staves where they butt together. This repair was accomplished by placing small steel plates at the joints and putting on additional bands. Portions of the line became so bad that it was necessary to build forms around the pipe and case it with reinforced concrete. I think in building a new line, redwood instead of fir would be used, on account of its greater resistance to decay, which would more than offset the difference in first cost. The total first cost of this line was $180,000, or $4 per foot.

In pursuance of the policy of obtaining all water possible by gravity, and in view of data gathered concerning run-off in the Duck Creek valley, a reservoir of 2,000,000 cu.ft. capacity was constructed at the intake. Search was made for additional reservoir sites along watercourses in the hills, but only three were suitable, two on upper North Creek and one on Berry Creek. As so often happens, the best sites were in locations where they were of the least value for water storage.

The two reservoirs on upper North Creek cost only $2,500, and each holds 2,000,000 cu.ft. of water. The

Berry Creek reservoir is formed by an earth-fill dam, 32 ft. high, has a capacity of 4,600,000 cu.ft., and cost $6,000.

Several Feeder Lines Constructed

In addition to building reservoirs, the company has also piped various small streams from the mouths of the canyons out to the main valley, passing the water over the porous material which is piled up against the hillside.

TABLE I. DIMENSIONS AND COSTS OF THE VARIOUS LINES.

	Length	Diameter, In.	Cost
Bird Creek	9,800	6	$15,000
Timber Creek	16,500	8	10,000
South Berry	8,500	8	5,500
Main Berry	20,000	12	15,000
Totals	54.800		$45,500

These feeders, listed in Table I, have steadied the daily flow, and have also prevented loss of water during the winter months, as the streams would freeze and spread out. Thus the average flow during the low-water months of December, January, and February, was for the last three winters, 13¼ sec.-ft., as compared with 10¾ sec.-ft. for the previous years.

With the exception of Bird Creek, these lines were built of light riveted pipe of such size that all of the available head was consumed in friction and but little pressure was developed at any part of the line. The pipe itself was built in the Nevada Consolidated shops, and the cost of labor and material has been between 6 and 7c. per pound. All pipe was dipped in asphaltum and drained on end. Twenty-foot sections were used, with male and female ends, forming what is known as "slip-joint" construction.

Method of Assembling the Pipe Line

In assembling in the field, a piece of burlap was dipped in coal oil, wrapped around the outside of the female end and set on fire. The heat expanded the pipe and softened the asphaltum so that the male end of the next piece could be entered and driven home very readily. When the pipe cooled, the asphaltum solidified and sealed the joint. The best progress was made by having a loosely fitting plug with a piece of ½-in. plate bolted to the back and forming a collar, which made it practicable to drive the pipe in by striking the plate with a wooden ram. A light tripod for supporting the ram completed the equipment. By this method three men could lay from 1,500 to 2,000 ft. of 8-in. pipe in eight hours.

Precipitation records have been taken at McGill for a number of years, and hourly measurements are taken on the discharge end of the Duck Creek pipe line. Although the line was intended to carry the entire flow, sufficient data were not available when it was designed. As a result there is a loss of as high as 4 to 5 sec.-ft. during the summer season of most years. Increased reservoir capacity has reduced this loss, but it still persists.

In addition to the seasonal variation of flow in Duck Creek, a marked hourly variation exists, particularly during the winter months, due to the alternate freezing and thawing in the mountains. As frosts occur in the mountains late in the spring and early in the fall, and the snow is rarely entirely melted before July, this condition of hourly variation must be reckoned with during eight or nine months of the year.

Bird Creek, with a flow of four or five second-feet, comes into Duck Creek at the main intake. This stream has a gradient of 4 per cent, and a small hydro-electrical plant was formerly contemplated at the junction of Bird and Duck creeks. Also, a test pit was sunk just below the main intake reservoir, and it disclosed a considerable underflow. In sinking, we passed through 10 ft. of loam, followed by 30 ft. of water-bearing gravel containing loose boulders, and encountered hardpan at 40 ft. A tunnel was then driven entirely across the Duck Creek valley below the intake reservoir in the gravel, and on top of the hardpan. Water ejectors handle the flow which developed as a result of this tunnel.

The power water is obtained from the Bird Creek pipe line at a pressure of 150 lb. per square inch, and the flow from the gravels has averaged nearly two second-feet.

Wet, Loose Ground Made Tunnel Driving Difficult Boulders Jacked Back

The driving of these tunnels involved considerable difficulty, as the ground was very loose, full of water, and contained boulders two or three feet in diameter. It was necessary to use breast boards and drive spiling ahead of the timbers, as the ground would run upon the slightest provocation. The boulders caused a great deal of trouble when partly in the tunnel, until we discovered it was possible to spile around them and then jack them back out of the line of the tunnel. The tunnel is 1,150 ft. long, and is from 40 to 20 ft. below the floor of the valley, the deepest part being in the center near the screen house at the pipe intake.

In an effort further to increase the flow, churn-drill holes were put down in the working shafts, one hole being put down 1,130 ft., striking rock in place at that depth. Little if any additional water was obtained as a result of the drill holes. At the smelter there is what is known as the McGill Springs, with a flow of from 9 to 12 sec.-ft. In order to supplement the gravity flow from Duck Creek during periods of low water, two motor-driven centrifugal pumps were installed at these springs, each pump having a capacity of 4.9 sec.-ft. against a head of 480 ft. This method of pumping is not particularly economical, and was subject to certain inherent objections, chief among which was the fact that the only way to govern the rate of flow was by starting and stopping the pumps.

A triple-expansion steam pumping engine has been installed, with a maximum capacity of 12 sec.-ft. Steam at 165 lb. pressure is to be piped 3,000 ft. through a carefully insulated line, and a coal-fired superheater in the pump station gives this steam approximately 50 deg. superheat.

As approximately 20 sec.-ft. of water are required for the operation of the mill and smelter, and as the flow through the Duck Creek line sometimes falls below that amount, pumping from the McGill Springs is necessary to make up the difference.

The pumping costs have ranged from $40,000 to $55,000 per year, and the quantity of water pumped from 140 to 220 million cubic feet, the cost per million cubic feet being from $240 to $325. This is exclusive of re-pumping in the mill.

With an increased mill tonnage, additional water will probably have to be pumped, but with the steam pumping plant the cost should be reduced materially, probably to $120 per million cubic feet, or a saving of from $15,000 to $25,000 per year.

Curves To Show What a Ball Mill Should Do

Charts, Based on Present-Day Practice, Serve as a Convenient Means of Determining Approximate Power Required, Size and Speed of Proposed Mills, as Well as Checking the Work of Operating Units

BY THOMAS E. FISHER
30 Church St., New York City
Written exclusively for *Engineering and Mining Journal*

THE tonnage which may be put through a ball mill, and the fineness to which it will grind, depend on several factors, among which may be mentioned:

1. Hardness of the ore and size of feed.
2. Rate of travel through the mill.
3. Percentage of water.
4. Size of balls and number of balls.
5. Speed of mill.
6. Open- or closed-circuit grinding.
7. Type of mill, center or peripheral discharge.
8. Size of mill.

Some of these are variable or under the control of the operator; others are fixed, once the mill is running. Maximum mill efficiency is obtained when the greatest

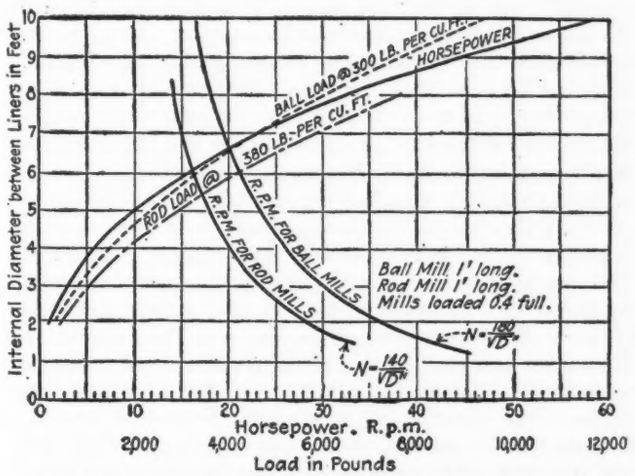


FIG. 1. CURVES SHOWING BALL LOAD, POWER REQUIRED, AND MOST EFFICIENT SPEED FOR BALL AND ROD MILLS

number of tons of ore is ground to the desired fineness in the shortest time, with the expenditure of a minimum amount of power and with the least wear on balls and liners. It is determined largely by the right combination of the factors above listed.

From the many excellent articles which have been written on current ball-mill practice, it is possible to gain information which will give a good idea of the correct combination necessary for the economic operation of proposed mills. No hard and fast rules can be formed, but, in general, the information gained will also prove useful in operating plants, as giving a means of checking the work done by any particular mill, and of correcting existing faults.

I will consider the factors mentioned in the order above set down:

1. Hardness of ore. This is beyond the control of the operator, but its size is not. Formerly, the tendency was to feed ore up to 4 in. in size. The more recent practice is to reduce the size of feed, for operators are determining the economic limitations of ball mills, and finding it preferable first to crush in jaw crushers, gyratories or rolls to 1 in. or finer.

2. Rate of travel. If the rate be slow, the ore is subjected to a greater number of blows, and is, of course, crushed finer. The tendency is, however, to feed fast and return the oversize, after classifying, for re-grinding. (See 6.)

3. Per cent of moisture. This will vary with the character of the ore. Good practice is to keep the moisture low and the pulp thick, so as to coat the balls. This is conducive to less wear on balls and liners.

4. Size of balls. Balls from 1 in. to 7 in. in diameter are used. In a given mill the size of balls should be determined largely by the size and hardness of the ore. Best results seem to be obtained when the mill is loaded between 0.3 and 0.4 full.

5. Speed of mills. This is properly a direct function of the internal radius, and is something less than the "critical" speed. The "critical" speed of any mill is that which will make the layer of balls next to the shell cling to the latter as the mill revolves. Davis shows this to be $N = \frac{54.19}{\sqrt{r}}$ where N = r.p.m. and r = radius in feet.

The modern practice is to operate at 0.6 to 0.8 of this speed. At 0.8 and above, the balls tend more to cascade, and the grinding is done largely by impact. At 0.6 the action is more of a rolling nature, and grinding is done by attrition, with less wear on the balls and liners. Operators are proving by decreasing the size of the feed that they may decrease the size of balls, increase the number in the mill, secure a greater grinding surface, cut the speed to secure a greater rubbing action, and do more efficient grinding. As the power is directly proportional to the speed, the slower the mill turns, the less the power required. Also, the slower the speed the less the capacity, so a most efficient speed exists for any particular mill, and this must be determined by experiments on the ore under treatment.

6. Open and closed circuits. The tendency has been to grind in closed circuit, crowding the ore through the mill, classifying, and returning the oversize. Good practice fixes this circulating load at from four to five times the feed. Closed-circuit operation tends to keep the mill up to full capacity, and is conducive to efficient working.

7. Type of mill. Opinion is divided as to the advisability of discharging the pulp through grates or overflowing through the trunnion without any diaphragm. The diaphragm makes the mill more sensitive to overloading.

8. Size of mill. The tendency is to the large-diameter mills; 9-ft. mills are the largest so far used.

With the above points in mind and with operating data from several mills at hand, I have constructed the curves shown in Fig. 1, with the idea of having a quick means of deciding on the prospective duty of a mill.

These curves are for a mill of any internal diameter between 2 ft. and 10 ft., and 1 ft. long. The ordinates show the inside diameters of the mill, with liners in place, in feet. The abscissas show speeds in r.p.m. and ball loads in pounds when the mill is 0.4 full. One plant manager has recently stated that the balls in his mills have an average weight of 280 lb. per cu.ft. Three hundred pounds is used in figuring the curves, the extra 20 lb. being assumed as covering the friction on gears, bearings and the weight of pulp in the mill. Speeds are figured from the formula $N = 180$, where D is the internal diameter in inches. I do not claim that this gives the most efficient speed, but it approaches the more recent practice. The power is figured for the loading at the speed shown.

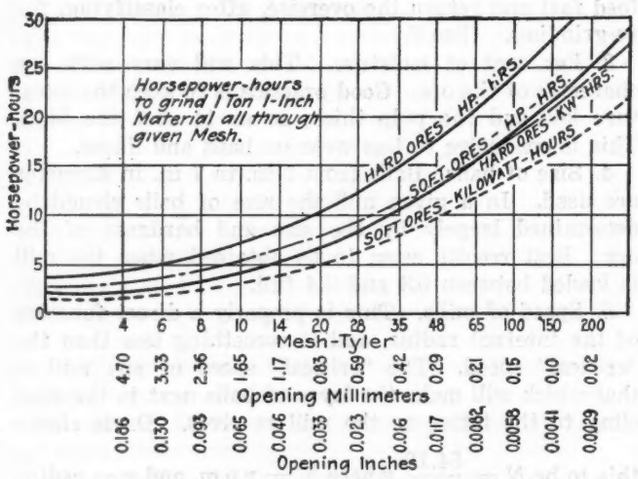


FIG. 2. CURVES SHOWING APPROXIMATE POWER REQUIRED TO GRIND ONE TON OF ORE THROUGH A GIVEN MESH

I will explain the use of the curves by an example:

Assume a 6 x 6-ft. mill. Assuming 3-in. liners, the actual internal diameter is 5 ft. 6 in. Entering the chart at the left at 5 ft. 6 in., the speed is found to be 22. The ball load shows 2,800 lb. per ft., or 16,800 lb. load at 0.4 full for a 6-ft. mill. For this load the power is $12.5 \times 6 = 75$.

Now, assume a 6 x 6-ft. mill loaded with 14,000 lb. of balls, running at 25 r.p.m.; what power will be required? As the power is proportional to the speed, $22 : 25 : : 75 : x$. Solving, $x = 85.2$. Although the power is not directly proportional to the loading, it may be so assumed for practical purposes.

Thus, $16{,}800 : 14{,}000 : : 85.2 : x$. Solving, $x = 71$. This is the power, then, required to run the mill. The starting power is considerably more, and allowance should be made for this in purchasing the motor.

Curves for rod mills are also given. As current practice shows that rod mills give good results at lower speeds, the formula $N = \frac{140}{\sqrt{d}}$ has been taken. No definite data have been published to show the weight of rods when in a mill, and 380 lb. per cu.ft. has been assumed as being near the correct figure.

A 4 x 10-ft. rod mill with 2-in. liners will show 16,000 lb. of rods when 0.4 full, and will require 50 hp. to operate at 21.2 r.p.m. As stated for ball mills, these figures may not necessarily be the best, and tests made in running may prove it advantageous to remove some of the rods.

If we accept as true the statement that for any particular ore a definite amount of energy is necessary to grind that ore all through a given mesh, we have a means of estimating probable capacities of ball mills.

Hines (Bull. A. I. M. E., Feb., 1918), published two curves, one for hard ores and one for soft ores. These curves, Fig. 2, are plotted from tests made in the field, and show the approximate amount of energy necessary to grind one ton of ore from about 1-in. size all through any mesh. An inspection of these curves shows that it requires 14 hp.-hr. (18 minus 4), to grind one ton of hard ore from 1-in. all through 48 mesh, and 10.5 hp.-hr. (13 minus 2.5), for soft ore. If, from Fig. 1, the 6-ft. mill requires 75 hp. input, then $75 \div 14 = 5.3$ tons per hour of the hard ore will be ground to 48 mesh, and 7.1 tons per hour of the soft ore. Obviously, the accuracy of the estimate will depend on how closely the hardness of the ore handled is judged.

Waterproofing Rectangular Wooden Tanks

ON INVESTIGATING the most economical method of making rectangular wooden tanks watertight, it was found that tongued-and-grooved plank, with an internal coat of P. & B. paint, proved unsatisfactory, the tanks leaking to a considerable extent, owing to the fact that it was not possible to procure lumber reasonably free from knots. Another method tried was to cut the planks with a calking seam, and calk with oakum, experienced calkers being employed for the purpose. The result was satisfactory, but somewhat expensive. Still another expedient resulted successfully. This consisted of the following: The planks were made with a calking seam as for oakum, but were purposely not planed. The seams were filled with ordinary portland cement, applied with a pointing trowel. A thin grout of cement, of about the consistency of cream, was then applied to the entire interior of the tank by means of a whitewash brush. When the cement was dry and hard, the surface was sprayed with a water hose, and another coating of the cement grout was applied. When this was dry, the tanks were filled. The results were excellent, the cement adhering well to the rough "hairy" surface of the undressed lumber.

This method of waterproofing would hardly be applicable to tanks subjected to considerable vibration, as jig hutches, or to large tanks repeatedly filled and emptied, as there would be a tendency to "spring," and the surface of the cement would be cracked. In the case of tanks kept constantly full, as a head box connected to a penstock, the method answers well. The cost is much less than that of tongued-and-grooved plank, and, moreover, it is possible to use poorer and cheaper lumber.

[Attaching fine-mesh wire netting to the inner walls of the tanks and coating with cement applied by a cement gun is suggested as an alternative to the method described.—EDITOR.]

Extremes of Practice in Ball-Mill Grinding are represented on the one hand by the Inspiration plant, in Arizona, where 3-in. material is reduced to minus 48-mesh at one operation, and, on the other hand, by the mill of the Canada Copper Corporation, where crushers and rolls reduce the ore to 10-mesh after which it is ground to 100-mesh by two-stage ball-mill reduction.

Tube-Mill Calculations

Ratios Between Tube-Mill Classifier Circuit and Original Feed and Examples Applicable to Practical Operating Conditions

BY GEORGE O. DESHLER
Mining Engineer, Columbia Gardens, Butte, Mont.
Written exclusively for *Engineering and Mining Journal*

IN TUBE-MILL grinding, it is desirable to know the exact ratio between the tube-mill classifier circuit and the original feed. Tonnage samples with this end in view are not acceptable, as it is practically impossible to determine the moisture in a pulp from a sample large enough to represent the tonnage accurately. This ratio can be determined easily from the daily screen tests.

Let

x = total original feed to classifier,
y = tube-mill feed (classifier sands),
A = per cent of finished size in the original feed (This will depend on the fineness of the overflow desired),
B = per cent of finished size in tube-mill feed,
C = per cent of finished size in tube-mill discharge,
D = per cent of finished size in classifier overflow.

Then

Ax = weight of finished size in the original feed,
By = weight of finished size in tube-mill feed,
Cy = weight of finished size in tube-mill discharge,
Dx = weight of finished size in the classifier overflow.

In regular operation, with the dry tonnage of the original feed equal to the dry tonnage of the classifier overflow, at any one instant in the cycle the weight of finished size in the material going to the classifier will equal the weight of finished size in the classifier products. Therefore

$$Ax + Cy = Dx + By$$
$$y = \left(\frac{D - A}{C - B}\right) x$$

What is required, then, for determining this ratio, is the percentage of undersize from the limiting screen, on the four products as stated above.

A few examples from practice will serve as illustrations. In the following work 15 per cent plus 65 mesh, Tyler standard screen, was desired in the classifier overflow.

EXAMPLE 1

Oversize in the overflow approximately as desired.

	Per cent
—65 mesh in the original feed	38.0
—65 mesh in the tube-mill feed	27.8
—65 mesh in the tube-mill discharge	49.2
—65 mesh in the classifier overflow	87.0

Applying the equation, $y = 2.29x$

EXAMPLE 2

Oversize in the overflow greater than desired.

	Per cent
—65 mesh in the original feed	29.8
—65 mesh in the tube-mill feed	30.4
—65 mesh in the tube-mill discharge	45.8
—65 mesh in the classifier overflow	80.4

By substituting, as before, $y = 3.28x$.

With a higher allowable amount of oversize in the overflow, the ratio of tube-mill feed to original feed increases, under the stated conditions.

EXAMPLE 3

Oversize in the overflow less than desired.

	Per cent
—65 mesh in the original feed	29.6
—65 mesh in the tube-mill feed	35.4
—65 mesh in the tube-mill discharge	81.8
—65 mesh in the classifier overflow	94.6

Using the equation, $y = 1.40x$.

As the amount of oversize in the overflow is decreased, the ratio of tube-mill feed to the original feed decreases, under the stated conditions.

It is the general practice in ball-mill grinding to run the feed direct to the mill instead of to the classifier, as in the cases considered above. With this arrangement, let

x = weight of original feed to mill,
y = weight of classifier sands,
A = per cent finished size in original feed,
B = per cent finished size in classifier sands,
C = per cent finished size in mill discharge,
D = per cent finished size in classifier overflow.

Then

Ax = weight of finished size in original feed,
By = weight of finished size in classifier sands,
$C(x + y)$ = weight of finished size in mill discharge,
Dx = weight of finished size in classifier overflow.

As before, the weight of finished size in the material going to the classifier will equal the weight of finished size in the classifier products, so

$$C(x + y) = By + Dx$$

or

$$y = \left(\frac{D - C}{C - B}\right) x$$

The ratio of circulating load (R) to original feed would be

$$R = \frac{x + y}{x} = 1 + \frac{y}{x} = 1 + \left(\frac{D - C}{C - B}\right)$$

EXAMPLE 4

As an illustration, suppose the figures are the same as in Example 1 except the percentage of undersize in the tube-mill discharge.

	Per cent
—65 mesh in the original feed	38.0
—65 mesh in the classifier sands	27.8
—65 mesh in the mill discharge	59.4
—65 mesh in the classifier overflow	87.0

Substituting in the equation, $R = 1.87$.

[Ed. Note.—Properly speaking, the circulating load is that part of the load which circulates, or returns to the starting point. In the case of the feed going direct to the ball mill, the circulating load is made up of the classifier sands only, as that is the only part of the original feed which completes the cycle. Following this concept, the ratio (R) of circulating load to original feed would be $R = \frac{y}{x}$ instead of $1 + \frac{y}{x}$ as given by Mr. Deshler. Further discussion is invited.]

The Peripheral Speed of Ball Mills should vary inversely as the fineness of grinding; from 375 to 400 ft. per minute for minus 48-mesh product, and 550 to 625 ft. per minute for coarse grinding, say 8-mesh. This was one of the points brought out at the recent flotation conference at Moscow, Idaho.

An Improved Zinc Feeder

Details of a Really Satisfactory Machine in Use at the Homestake Mill for Feeding Variable Amounts of Zinc Dust

BY ALLAN J. CLARK
Metallurgical Engineer, Lead, S. D.
Written exclusively for *Engineering and Mining Journal*

THE technique of precipitation has advanced more in recent years than has any other department of cyanide treatment. Without going into details, it may be stated that one pound of zinc dust is now as efficient as twice that amount was a few years ago.

To obtain the full advantage of the improvements, extreme precision in the feeding of zinc is necessary. This may be gathered from the fact that the regular rates of feed at the Homestake mill range from 4 lb. to as little as 1¼ lb. per hour. The feeder herewith illustrated was designed to secure this uniformity of feed. Fig. 1 illustrates the original installation, which was driven from the pump shaft. This method was rather unsightly and was also open to the objection that a slight slip of the belts on the pulleys occurred. It soon became apparent that the expenditure necessary for an independent drive was justified, and an electric motor, delivering its power through a double worm-gear reduction, has displaced the original device. This has proved neat and eminently satisfactory.

The drawing is self-explanatory. The gentle blows delivered by the small stamp to the axle of the forward pulley of the feed belt cause the zinc particles to break away soon after the belt passes from the horizontal, much sooner than would be the case were this gentle vibration not maintained. The dust slides easily, and in small aggregates, to the emulsifier. A comb-like device is sometimes used as a further precaution against the breaking away of larger aggregates of zinc. This is placed about midway between the discharge point of the belt and the emulsifier, at a point where the zinc is still sliding on the leather surface. It is not shown in the drawing. When a cyanide drip is used, the device shown in Fig. 2 gives uniformity of strength and rate with minimum attention.

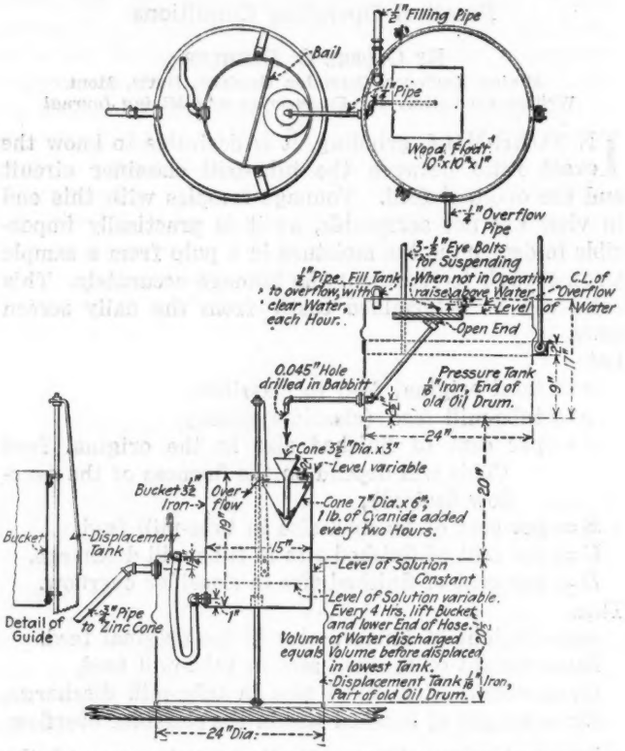

Filling Pipe
Bail
Pipe
Wood Float 10"x10"x1"
Overflow Pipe
Eye Bolts for Suspending
Pipe, Fill Tank to overflow, with clear Water, each Hour.
When not in Operation raise above Water Level
C.L. of Overflow Water
Open End
0.045" Hole drilled in Babbitt
Pressure Tank Iron, End of old Oil Drum.
Cone Dia. x Level variable
Bucket Iron
Over-flow
Cone Dia. x, 1 lb. of Cyanide added every two Hours.
Bucket
Displacement Tank
Level of Solution Constant
Level of Solution variable. Every 4 Hrs. lift Bucket and lower End of Hose.
Pipe to Zinc Cone
Detail of Guide
Volume of Water discharged equals Volume before displaced in lowest Tank.
Displacement Tank Iron, Part of old Oil Drum.
24" Dia.

FIG. 2. DISPLACEMENT TANK FOR CYANIDE SOLUTION

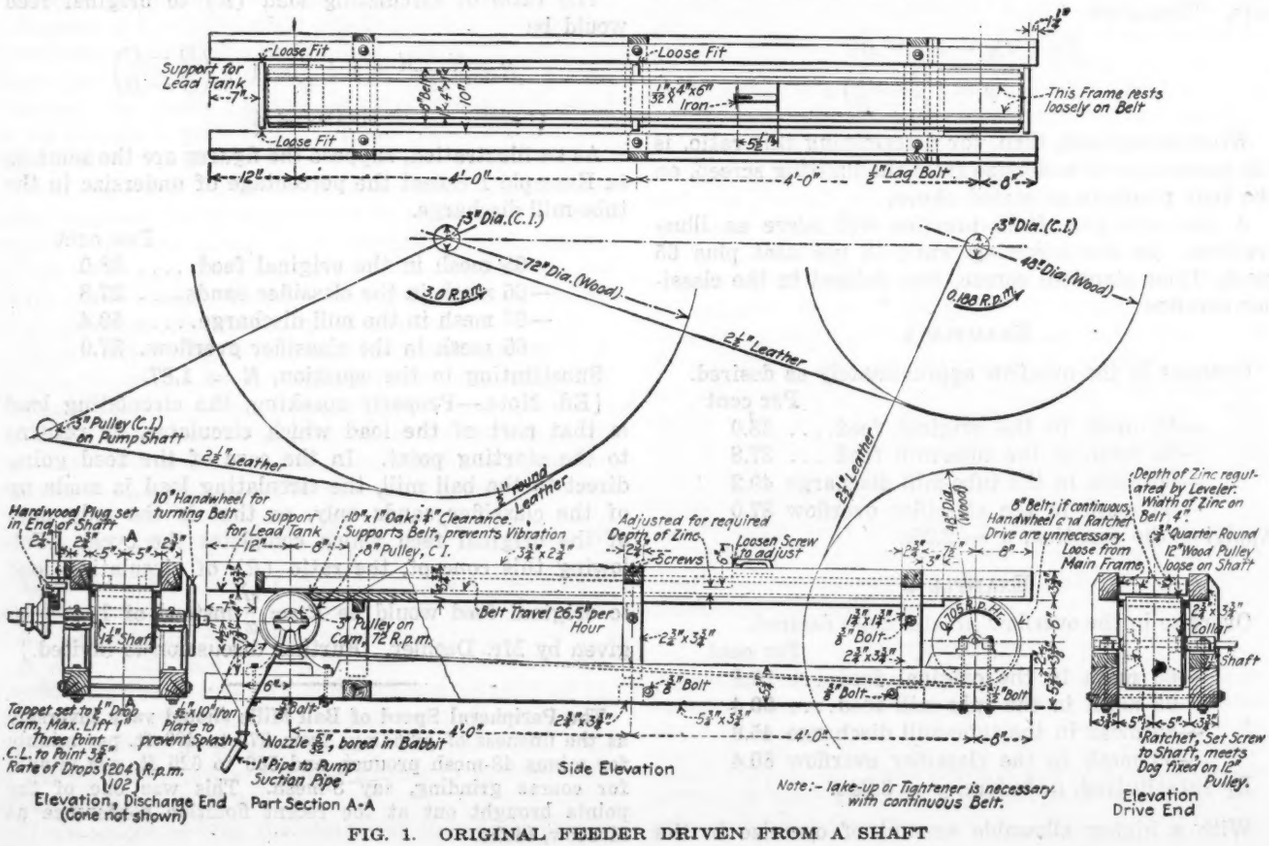

Support for Lead Tank
Loose Fit
Iron
This Frame rests loosely on Belt
Lag Bolt
3" Dia. (C.I.)
72" Dia. (Wood)
43" Dia. (Wood)
3.0 R.P.M.
0.198 R.P.M.
2½" Leather
3" Pulley (C.I.) on Pump Shaft
10" Handwheel for turning Belt
Handwood Plug set in End of Shaft
Support for Lead Tank
Supports Belt, prevents Vibration
8" Pulley, C.I.
Adjusted for required Depth of Zinc
Loosen Screw to adjust
Belt Travel 26.5" per Hour
3" Pulley on Cam, 72 R.p.m.
8" Belt; if continuous, Handwheel and Ratchet Drive are unnecessary.
Loose from Main Frame
12" Wood Pulley loose on Shaft
Depth of Zinc regulated by Leveler. Width of Zinc on Belt 4".
Tappet set to ½" Drop Cam, Max. Lift 1"
Three Point C.L. to Point
Rate of Drops
R.p.m.
Nozzle bored in Babbitt
Suction Pipe
Elevation, Discharge End (Cone not shown)
Part Section A-A
Side Elevation
Note:- Take-up or Tightener is necessary with continuous Belt.
Elevation Drive End
Ratchet, Set Screw to Shaft, meets Dog fixed on 12" Pulley.

FIG. 1. ORIGINAL FEEDER DRIVEN FROM A SHAFT

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Western Editor

D. E. A. CHARLTON
Managing Editor

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METALS NON-METALS PETROLEUM

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News Editor

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BENJAMIN L. MILLER
J. VOLNEY LEWIS
Special
Consulting Editors

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Hoover for President

THE most prominent mining engineer in the world, both as engineer and citizen, has indicated in a telegram to the Hoover Republican Club of San Francisco his consent to be candidate for President on the Republican ticket, with the understanding that he is essentially an independent or progressive. His platform, as announced in the same telegram, is as sound as his personality: "I understand that there is a great wish among the Republicans of California to have opportunity to express themselves in favor of the League of Nations, with proper reservations safeguarding American traditions and interests, as opposed to the extreme view advocated against any league at all. I differ just as strongly with this view as I differ with the extreme position taken by the President on participation in purely European affairs. This issue is whether, with reservations protecting our position, we should join the moral forces of the world to reduce the dangers again growing around us, or whether we will, by pretense of an insularity that we do not possess, sit by in the face of growing armies, navies, national antagonisms, reaction, or, in reverse, the spread of Bolshevism, through much of the world. This would be the defeat of the hopes for which our sons were sacrificed in this war."

Hoover will be opposed by the machine Republicans more bitterly than the machine Democrats would have opposed him had be announced himself as on the Democratic side—until after the Republican convention; but if he should be nominated there is no question that he would be elected by an overwhelming majority of Republicans, Democrats, and independents, the last named of whom are increasingly powerful. Party lines will in any event be split in the election, and the issue to be fought out is the League of Nations and the Peace Treaty. The "irreconcilables" of both parties who are opponents to any participation by the United States in the affairs of the world will line up together against the advocates of a League of Nations, made safe for America. It is almost certain that the advocates of the League of Nations treaty as the President insists upon it will drop out of sight, so that, instead of the late three-cornered fight, we shall have a clearly defined issue before the country.

It is significant that amid the clamor of irritation from the machine Republicans, one does not hear any objection on the part of the Democrats. Our guess at the situation is this: The Republican convention comes before the Democratic. *If the Republicans do not nominate Hoover, the Democrats will.* The Republican machine understands this; hence the spleen of those Republicans composing it. With Hoover as candidate, or without Hoover in the field, they feel certain of victory. With Hoover as the Democratic candidate, they do not feel so sure; and they have good grounds for their doubt.

We believe that the *Engineering and Mining Journal* was the first publication which formally advocated Hoover for president. From an editorial in our issue of Sept. 27, 1919, we quote the closing paragraph:

"The *Journal* presents for nomination for President of the United States of America at the election of 1920, Herbert Clark Hoover, Servant of Humanity."

The Problem of the Low-Grade Semi-Oxidized Copper Deposits

WITH the depletion of the world's supplies of high-grade sulphide copper ores, metallurgists are turning to the development of economic processes for treating the enormous deposits of comparatively low-grade ores which exist in many places. Particularly successful have been the installations of the Utah Copper Co., the New Cornelia Copper Co., at Ajo, Ariz., and the Chile Copper Co., at Chuquicamata. Tabling and flotation are employed in the case of sulphides, and leaching where the ores are oxidized.

In many cases the immense deposits consist of sulphides at considerable depth, with a capping of oxidized ores, the dividing line being by no means sharp, so that a somewhat complicated and closely regulated process of extraction must be used. Leaching, followed by re-grinding and subsequent flotation, has been successfully employed, the leaching coming first, principally because flotation requires finer grinding and for the reason that many sulphide particles have an oxidized surface.

The importance of considering the advisability of roasting followed by leaching, with the elimination of flotation treatment, must not, however, be overlooked. In many cases it may be a cheaper method. Cheap and proper roasting is of particular importance in this connection. It is discussed by W. L. Maxson elsewhere in this issue. The Shannon ores offer one of the most difficult treatment problems to be solved in the reduction of the ores of the Southwest. Several methods were tried before the one described was adopted—the Slater process, the SO_2 method proposed by Leaver and Van Barneveld, of the Bureau of Mines, and the ammonia process; but none was successful.

When the plant was closed down last year it is understood that plans were under way to duplicate on a commercial scale the plant outlined by Schimerka, in *Engineering and Mining Journal* of Dec. 13, 1913. This consisted in using ferrous sulphate, obtained from evaporating iron liquors, as an addition to the roaster charge, obtaining a high conversion to ferric sulphate (keeping it below its decomposition temperature), and using the ferric liquors as leaching reagents. The main objection to this process would probably be the throwing down of the dissolved copper as a double salt with iron, when the concentration grows too high.

Fine Grinding

ANOTHER year sees the ball mill still pre-eminent in American milling practice as a fine grinder. Although not in all respects a scientific machine, its adaption to small or large units, its relative freedom from trouble, the small amount of room which it occupies, and the attention which it has had from manufacturers, have made it a general favorite for the final grinding preliminary to table or flotation concentration.

The stamp mill, however, must not be forgotten, as Mr. Clark tells us elsewhere in this issue. Younger metallurgists, and also those who are not in touch with the metallurgy of gold and silver, will find a perusal of Mr. Clark's article well worth a few minutes of their time. The rod mill must also be considered. It has been said that this type of mill was born too late; that its comparatively slime-free product is excellent feed for tables, but inferior to that of ball mills for flotation purposes. However, rod-mill development has gone forward; the Marcy mill people have done considerable work, and recently some extremely interesting tests have been completed at the Ajo test mill of the New Cornelia company, in which David Cole has been interested. The data secured in this work are now being compiled, and we hope soon to publish more complete information.

The Ajo tests were made with a 5 x 10-ft. rod mill in direct competition with a ball mill, and the final results are expected to show the former in a particularly favorable light. When the rod mill was first introduced, many mechanical difficulties were encountered, and the elimination of these has been the chief aim of its developers.

The excellence of the better-known makes of ball mills from a mechanical standpoint has been a great factor in putting them in the position in which they stand today, and equal thought and care spent on the rod type may make the latter a sharp competitor. The so-called tube mill, similar in construction to the ball mill, only more elongated, still retains its pre-eminence where the object is sliming. Where iron in the product is of no disadvantage, the choice between steel balls and rock pebbles as the grinding medium is purely a question of comparative cost. The cost for steel will, in general, be greater per ton ground, but the mill capacity wil' be greatly increased.

Improving Transportation in Colorado

COLORADO voters are to have submitted to them at the election next November an amendment to the state constitution authorizing the creation of a commission to construct three tunnels through the continental divide and providing for an issue of bonds to pay for them. This engineering project has been pronounced feasible by the railroad commission empowered by the last Legislature to study the matter. In the preliminary report just issued by this body, the plan set forth calls for boring through the divide near James Peak, in northwestern Colorado; at Marshall's Pass, in the midwestern part of the state, and at Cumbres Pass, in the southwest. These tunnels are to be 6¼, 6 and 1¼ miles long, respectively, the cost being estimated at a round million per mile.

Thus the work of lessening the time and ultimate cost of transportation goes on, and nowhere is there a better chance for it than in Colorado. The beauties of mountain scenery offer scant relief to the traveler cussing his way from Denver to Salt Lake over the Rio Grande, as the train crawls slowly up over the divide at an altitude of about 11,000 ft., and down on the other side. It sounds like old times when new railroad development is again spoken of, and augurs well for the future. The country needs this particular improvement, but Colorado needs it more.

Medical Examination of Hoisting Engineers

IN METAL MINES, hoisting engineers have a definite and heavy responsibility, even in the case of small properties. Superintendents and managers are aware of this, and as a rule take particular care in the selection of men for the position. The selection is based on the engineer's past experience, his current knowledge of the type of hoist to be entrusted to him, and the superintendent's general estimate of the man, as a man.

Forming judgment as to a man by just looking him over is a good enough method where there is nothing better, but there are obvious limitations; sight, hearing, and general physical condition cannot always be safely determined by a casual inspection. Nevertheless, a keen observer can, by relatively simple tests and careful scrutiny, reach an accurate conclusion on these points. It is worthy of note that in the selection of locomotive engineers, railroads have systematized such tests and apply them. Whether they also undertake to have a physical examination made by a competent physician, we do not know, but it appears to us to be a highly desirable procedure. It also is our opinion that a similar examination is advisable in the selection of a hoisting engineer.

How well has the casual method of selection operated in the case of hoisting engineers? This question has been answered in a specific instance, at least. We refer to the findings resulting from the medical examination of eighty-one hoisting engineers in Utah. The occasion was the formulation of rules for the licensing of hoisting engineers by the Industrial Commission of Utah. According to an account given in the Monthly Reports of Investigation of the U. S. Bureau of Mines, January, 1920, C. A. Allen and Dr. A. L. Murray summarize the findings respecting the physical well-being of these eighty-one applicants. Eighty-two per cent were between the ages of twenty-five and fifty-five years. The youngest applicant was twenty-two and the oldest sixty-six years old. In all except thirteen instances the applicants had experience covering more than one year. In most cases the applicants were in good physical condition; only two warranted the refusal of certificates. In several cases where the eyesight was defective but capable of correction by properly fitted glasses, action was held in abeyance. Twenty cases of defective vision without glasses were shown. Most of these disabilities were very slight, and all were corrected by glasses except three. Four cases of minor defects of limbs were reported, but in no instance was it of sufficient consequence to bar the applicant from the position of hoisting engineer. Three cases of hernia were reported, two of which were relieved by suitable means.

The net result of this particular survey is on the whole excellent, in that it proves a high degree of care in selection. We believe that a similar result would be obtained in any other mining state. Nevertheless, we are of the opinion that the need for a careful "sizing up" of the physical condition of the hoisting engineer

has been proved by this survey. The proportion of engineers unfitted on account of a critical defect is small, it is true, but considerations of safety are such as to make it highly desirable to eliminate this small proportion. A medical examination should be required by the superintendent or other individual charged with the selection of hoisting engineers at a mine, whether state laws compelling such procedure are in force or not.

The Psychotherapist in Oil

AMONG the advertisements of mining stocks which we regard with suspicion is that of the General Oil Co., put out by the Prudential Securities Co., of Houston, Tex., under the following headlines (in red):

FAMOUS DOCTOR AND LECTURER DEFINES THE BIG SPRING
DISTRICT AS VAST OIL EMPIRE OF UNLIMITED POSSIBILITIES AND GOLDEN PROMISE
OIL RUNNING ON THE DITCH AT SANDHILL WELL
THE POSSIBLE VALUE OF AN OPTION ON STOCK OF THE GENERAL OIL COMPANY

After the usual preliminaries, the circular states:

So that you will better appreciate the possibilities of profit contained in these options which we give to each purchaser of stock in THE GENERAL OIL CO., I am enclosing a telegram received from a famous lecturer and doctor, who came down from New England to investigate our company, and after spending three or four days in the Wichita Falls district, and two days in our office at Houston, he was thoroughly satisfied, but I prevailed upon him to continue his trip to Big Spring, and the enclosed telegram is the result of his investigation there.

This man, Dr. Delmer Eugene Croft, is a famous writer, lecturer, and psychotherapist, whose home is in New Haven, Conn.

The italics are ours.

The circular goes on:

I want you to note particularly the following points in his telegram. He says:

In the telegram our psychotherapist states in part:

Here is not an oil field but a *Gigantic Oil Empire.* A vast area of limitless possibilities and golden promise. Geographic and Geological formation like Pennsylvania red clay shale white sand lime rock flint gravel. . . . Neal and McDowell look slow but rich. Reed sector an immense possibility typical Pennsylvania draw. Roberts strongly volcanic basis and believe will be a big gasser. I predict a big well. Indexes most interesting Glenco California formation. . . . Predict foremost oil sensation of state will be uncovered in General Oil holdings in West Texas fields. . . . *Affirm your tract lies directly line between Ranger and Tampico.* For myself I am thoroughly convinced. Shall consider myself fortunate to hold General Oil shares. DR. CROFT.

A psychotherapist, we understand, is a physician who heals mental disturbances. We do not recommend, dear Doctor, the Oil treatment. Oil on the brain lubricates the wheels, and the revolutions become terrific. But we think it was a happy thought for the General Oil Co. to employ a psychotherapist as expert. When under the influence of Oil he unfolds his powers as a psychic and indulges in prophecies: "I predict a big well." "Predict foremost oil sensation of state," and even, more boldly, "Affirm your tract lies directly in line between Ranger and Tampico." His geology reveals evidence of what we might term multiple clairvoyance. The property, it appears, is altogether like Pennsylvania, California, and Texas. We credit the last. For these reasons, he buys.

Gentle reader, what more is needed to lubricate and slip open the clasp of your wallet?

Mining Engineers—Real and Bogus

THE bill which is to be introduced in the next session of the Arizona Legislature for the licensing of engineers is a step in the right direction, but who is to decide as to whether the so-called engineer has a right to the title or not? The honorable title of mining engineer, for example, certainly could not be confined to one who had secured that degree at a technical school. The ordinary type of examination would hardly do, for too many of us would flunk. Presumably, the granting of the license will depend upon training and experience, but where will the line be drawn and who will draw it?

We venture to suggest that the plan adopted by the national engineering societies would be satisfactory. All engineers who are members might be given licenses without question; a license could then be extended to others whose records were worthy and who were acceptable to the former grantees.

The licensing system does not appeal to most mining engineers, but as laws on this subject are going on the statute books of many of the states, we must use our best efforts to see that they are made as equitable as possible.

A certain type of mining engineer could well be dispensed with. Men of this type flaunt their self-given title before the public whenever possible, and often work in collusion with promoters and brokers. All companies whose stock "sells for 5c. until Friday; after which it will be advanced to 10c.," require the services of "a well-known mining engineer" to tell the public it cannot lose. Such engineers would be too well known to secure a license under the proposed system.

Has the Worst Arrived?

THE cost of living has shown no pronounced tendency to drop, and many mining companies are finding it increasingly difficult to keep their men contented. Many such companies, particularly those whose chief products are copper or gold, are really not financially able to increase wages in the proportion which they feel is just to the workmen, but in most cases the employees understand the status of things and are reasonable in their demands. It is not so hard to bear adversity if we know that all classes in our community are sharing it and that no one is profiteering at our expense.

The Homestake company has increased its wage scale beginning March 1, and now pays underground miners $5. Other companies are taking steps to cut the cost of necessities wherever prices seem exorbitant, either by promoting co-operative stores, selling supplies at cost, as at Tonopah, or bringing the producer and consumer into closer touch by farmers' markets.

Specialists in business conditions tell us that the peak of high prices has arrived, and that the close of the year will see the familiar curve headed southeast. The state of foreign exchange is one of the signposts: Europe cannot afford to buy from us at the present premium, thus increasing our supplies by the amount which would normally be exported. Also, we can increase our commodity stocks by buying in foreign countries at a considerable discount. If prices really are coming down, mining companies and others should, of course, keep their reserve supplies of materials at the lowest possible point consistent with a regard for continuous and economical plant operation.

WHAT OTHERS THINK

Is It True?

THE problems in dynamic geology recently propounded by Mr. Spurr are of great interest and stimulating to the imagination. However, as he has started out with the statement that he has not an idea as to the solution, it calls for a certain temerity on the part of a geologist of less experience to make any attempt to solve this problem. None the less, the observed facts would seem to indicate the possibility of a rational explanation, and I have been led to attempt something along these lines in the following notes:

In approaching the problem first propounded by Mr. Spurr—that is, to rationalize the observed fact that in general the dip of metalliferous veins is about 70 deg.

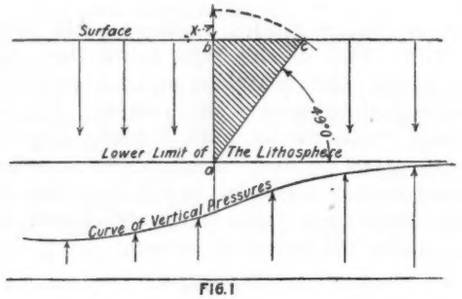


FIG. 1

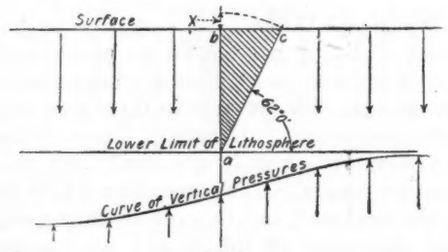


FIG. 2

from the horizontal—it is necessary to assume certain facts or conditions, and I believe that the following are reasonable:

First: That the faulting or fission of rocks at a high angle to the horizontal is due primarily to vertical forces originating in the zone of rock-flowage (the centrosphere of Van Hise) and resisted by the force of gravity acting upon the mass comprised in the lithosphere (zone of fracture).

Second: That such faulting is progressive in character, from the point of initial yield (presumably at the line between the centrosphere and the lithosphere—obviously an indeterminate point) upward, this assumption of progressive shear being consistent with the condition of maximum forces at great depths, and the elasticity of the material, which would provide progressive relief as the zone of shear extended.

Third: That for purposes of investigation it is proper to assume that the force that acts against gravity is practically fluid in its nature, is vertical in direction, and varies from a point of maximum intensity to zero at the limits of the affected area.

Proceeding upon these fundamental assumptions, we can take as a further basis the observed facts of normal faulting, in which the foot wall rises with respect to the hanging. Referring to Fig. 1, which is typical of a normal fault, it is seen that the cross-section sheared when the fault is at an angle of 49 deg. from the horizontal is increased by the amount x, which is about 0.245 above that of a vertical section from the point a to the surface. But it is also seen that the force of gravity acts through an additional mass equal to the area of the triangle a-b-c.

Ignoring for the sake of simplicity the factors of friction and the actual direction and force through which this additional weight acts,

$$\frac{sin\ 49\ deg. \times cos\ 49\ deg.}{2} = 0.246,$$

which is the value of this influence, and which corresponds quite closely with that of the additional section that must be sheared by virtue of the angle of the shear plane. From this it would appear that, on this rough basis, the theoretical angle of shear or faulting is 49 deg. In other words, the maximum condition of stress will exist at this angle.

However, the above rough example does not take into consideration the effect of friction upon the character and direction of the forces. This element of resistance must in itself be serious, as the contact of the surfaces is intimate, and certainly a high coefficient of friction can be safely assumed. Still ignoring any complexities that might develop as to the direction through which the force represented by the area of the triangle a-b-c acts, the effective vertical value of this force must be reduced by an amount equal to the friction, so that, if the conservative figure of 0.30 is assumed for this coefficient, and taking tentatively an angle of 60 deg., we have an additional section to shear equal to 0.137, and, by the same method as used above, an additional gravity element of 0.144 applying the coefficient 0.70 to the product of $\frac{sin \times cos}{2}$ as before. Here we see that the values again nearly check, but this time, on account of taking into consideration the friction element, the angle is seen to be approximately 60 deg.

I believe that it becomes clear that under the conditions assumed, and which seem normal to the data, vertical shearing is not to be expected, but that this shear must always be at an angle, and always be toward the center of vertical force, from the point "a" upward. This not alone accords with the observed facts of normal faulting, but also with the fact that a short test piece of non-ductile material under destructive compression yields by diagonal shear, normally leaving an uncomminuted, roughly conical or pyramidal core. With forces acting under the conditions outlined above, it is to be expected that substantially the same results would be observed.

It is possible that more careful study of the composition of the forces assumed would indicate that the ver-

tical value of the gravity element represented by the triangle *a-b-c* would be proportional to the sine of the angle of the shear-plane, in which case it is obvious that this angle must be still higher, in order that the additional section (*x*) to shear should be reduced to a point consistent with the residual net value of the gravity element in the triangle *a-b-c*. (Fig. 2.) A rough examination along these lines indicates the critical angle as approximately 62 deg., which is rather close to the observed conditions in the field.

Though I have made no effort toward the elaboration of anything that might be dignified by the name of a theory, I believe that the reasoning followed has, to the extent that it has been carried, a rational application to the facts to which Mr. Spurr has called attention.

One further remark will be ventured. It seems to me that horizontal thrust is normally a small factor in the phenomenon of faulting, as its effect would be negative, and would be manifested in a reverse fault only. I believe that the assumption of progressive shear and of vertical forces within the zone of the centrosphere is the only one consistent with the ordinary facts, and especially with the formation of a normal fault, although it is obvious that many incidental forces have their effect in determining the direction and magnitude of the actual movements.

GEORGE SYDNEY BINCKLEY.

New York, March 19, 1920.

Ozocerite in Wyoming

I am mailing you a sample belonging to the ozocerite group of hydrocarbons which is probably a new variety of the group named. The mineral occurs, in shapes resembling an ordinary pepper-pod, on a ranch near Bell Spring's Camp, Rawlins, Wyo. The hydrocarbon is more or less scattered over the surface of the hills and there is a lot of it in sight.

The sample has a high melting point (near 80 Celsius), which would place the substance near the Roumanian (Moldavian) ozocerite known as zietrisikite. It is far removed from such minerals as hatchettite, mellilite, or mellite, and it is more than likely that it is different from all other hydrocarbons so far described. It floats on water until fully saturated, and then sinks, but sparingly in the named liquid. It is insoluble in ether and alcohol, and but slightly soluble in turpentine or carbon disulphide.

I am proceeding further on the mineral by analyses and for classification. Meanwhile, this short description is submitted to you. R. O. H.

San José, Cal., March 24, 1920.

Magnesite Tariff Bill

With regard to C. S. Maltby's communication in the March 20 issue of *Engineering and Mining Journal* I would like to furnish some further amusement to Mr. Maltby.

The two main uses for magnesite are as a refractory material and as a chemical in the plaster, tile, and paper-pulp business, with the major consumption for refractory purposes. One of the petitioners for a tariff on magnesite testified that in 1917 the mines in California and Washington produced 316,000 tons. The further statement was made that 250,000 tons are required per annum by the refractory trade in the United States. The sworn statements of costs per ton of calcined or dead-burned magnesite of the six largest magnesite producers in the United States are as follows:

Northwest Magnesite Co.	$21.09
Porterville Magnesite Co.	28.43
Tulare Mining Co.	24.97
Western Magnesite Development Co.	24.16
White Rock Mines	28.22
American Mineral Production Co. (estimate of future costs)	23.54

The first and last companies are situated in Washington and the others in California. I would like to ask Mr. Maltby why the California magnesite mines are not producing more magnesite than they are at this time, when there is practically no competition from abroad. The importations in the last six months of 1919 were about 7,500 tons. Perhaps the answer is found in the cost figures, especially as one witness at the hearings testified that the Northwest Magnesite Co. should produce dead-burned magnesite for $14.51 per ton, including depletion and depreciation.

The uncontroverted statement was made at the last hearing before the Senate committee, the information being gathered in December, 1919, and January, 1920, that the California production was 98 tons per day of light-burned magnesite, which would mean only about 36,000 tons per annum, and that 279 men were employed in this mining industry in California. I would ask Mr. Maltby to explain how he expands 279 men into "a great many miners in California whose living at the present time is dependent on the magnesite industry."

The California magnesite is much better suited for other purposes than for making refractory material. The trouble with Mr. Maltby and his associates is that they have hitched their tails to the kite of the producers of magnesite for refractory purposes, which is the more important production from a tonnage standpoint. Would it not have been better if California producers had asked for protection against Grecian magnesite and the Washington producers for protection against Austrian magnesite, and not mixed their brew in the same kettle? F. F. COLCORD

New York, N. Y., March 25, 1920.

Gold Excise and Premium Proposal

I have just read your interesting editorial entitled "What Would Happen?" published in *Engineering and Mining Journal* of March 6. The premise which you have adopted affords a direct one upon which to base a more detailed presentation of the solution of the gold problem, and I herewith submit a brief discussion of the editorial.

Should the gold miners cease to present their gold to the U. S. Mint for sale at $20.67 an ounce, they would have no market for it at a premium so long as the Mint sells gold for $20.67. This must be evident; consequently, the first step would be to have the Government stop all sales of gold to the consumers of it in manufactures and the arts. This would immediately establish a premium market for the producers' gold, because it is obvious that the consumers of gold in manufactures and the arts would have to purchase gold, and, if they could not get it from the Mint, would have to buy it elsewhere at a price dictated by the law of supply and demand, or consume gold coin of

the United States. The fact is that we have no law in this country to prohibit the destruction of gold coin, such as exists in nearly all other nations. A large amount of gold coin is destroyed even under present circumstances, and if the Mint should withhold all gold from consumption in the arts and trades, that action would certainly increase the amount of gold coin destroyed, regardless of whether we had a law prohibiting the same or not.

In the event of a premium market established by withdrawing the sale of gold from manufacturers, the mere suggestion of such a proposal would cause the consumers of gold in manufactures and the arts to hoard the metal; whereas, under the excise proposal, the tax is imposed only upon the manufactured product, and, therefore, there will be no incentive to hoard the metal in anticipation of the excise, as it makes no difference whence the gold comes. To establish a condition which would enable the holders of old gold to profit in a speculative market would in no way have a tendency to increase the production of new gold, which is the really desirable thing to do at the present time. The market price of gold would vary from day to day, which would not only be unsatisfactory as a basis for the producer of new gold, but also from the standpoint of the consumer in manufactures and the arts.

This is the reason why the excise and premium proposal has many decided advantages over any other suggestion which has yet been presented. It merely creates the machinery by which the consumer of gold in manufactures and the arts may pay more nearly the cost of production for his raw material. It does not change the monetary unit, because the excise is imposed upon the manufactured article, and the premium is to be paid from this special fund to the producer of the new gold ounce in currency. If the excise and premium proposal were adopted, the manufacturer of gold would have the advantage of knowing that he would be supplied with gold sufficient to meet his requirements at definite and fixed cost to him on the manufactured product, and the producer would also know definitely what he was to receive for newly produced gold. This would have a decidedly stabilizing effect on the production of both of these industries.

The most serious objection, however, to withdrawing the sales of gold from the trades, thereby creating a premium market, is that the United States would be forced to accept all of the disadvantages which would accrue from a premium market as against the free gold market which now exists. The gold excise and premium proposal does not affect the bullion price of the metal in the least, as the Mint will continue to sell gold to the trades at the same monetary price of $20.67, and this will make possible the maintenance of a free gold market. The gold excise and premium proposal operates, therefore, wholly outside of the monetary circle, and is a transaction limited to the consumer and producer of gold.

There are some who have drawn the conclusion that the premium proposal is a subsidy to the gold producer. This is not so, because the Government has been and is now subsidizing the consumers of gold in manufactures and the arts. The wholesale index price number of all commodities in 1919 was 212, as compared to 100 in 1914, which shows, that had gold increased in price in conformance with all other commodities in the United States, the gold producer would have received for his 58½ million production in 1919, $65,500,000, or 112 per cent more than the monetary price which he did receive. The excise to be imposed upon manufacturers of gold merely lessens the amount of this subsidy. The $10 excise is an increase of 50 per cent in the price of the metal, but all commodity prices have risen 112 per cent; consequently, the excise offsets only 45 per cent of the subsidy now in force, and which, because of the fact that the Government sells gold to the trades at the original monetary price, must be and is being met by the producer. The proposal therefore cannot be construed as a subsidy to the gold producer. H. N. LAWRIE.

Washington, D. C., March 15, 1920.

A Cure for Fogged Lenses

Many times in mine surveying, when taking a transit from a warm drift to a cold one, the lenses and glass portions of my instrument have become fogged, and I have often lost my patience and valuable time at a critical moment. Last month I found a remedy for fogging. This consists of nothing but the anti-dimming compound that was issued to the boys in France to use on the inner surfaces and eyepieces of their gas masks to prevent dimming and fogging. This anti-dimming outfit comes in a lead tube about the size of one's thumb and is wrapped in a small piece of canton flannel that is used to apply the composition, which has the appearance of white vaseline. The outfit is contained in a tin box about the size of a shaving stick. One application to the glass portions of the instrument a week will do away with the fogging on the outside of the instrument.

A tube of this anti-dimming compound was issued with each gas mask, so that it may be possible to secure a sample from any ex-A E Fer. FRANCIS E. EVANS.

Picher, Okla., March 11, 1920.

Conserving Silver for Currency

It occurs to me that, even if a larger amount of gold cannot be forced into use as money, where it is so much needed, it should be possible with more hope of success to attempt this in the case of silver. On account of the present high price, it might be possible now to go on a two-metal standard, in order to protect the general money situation with a greater reserve of hard money. If this were not possible, why could not a start be made by charging a decided premium on silver used in the arts, photography, and articles of luxury, as compared to the silver used for money? Could not the Government take silver production at current market prices and charge a high tax on the amount used in the arts, conserving silver for monetary purposes and also obtaining revenue?

Again, as a further and less reasonable suggestion, is it possible through some special alloying process to freeze silver into exclusive use for currency? I suppose if this were possible it would already be done, particularly in France, in all new coinage. This idea is for the Government to develop some special alloy for its coinage, such that it could not be melted down and used for any other purpose. F. W. P.

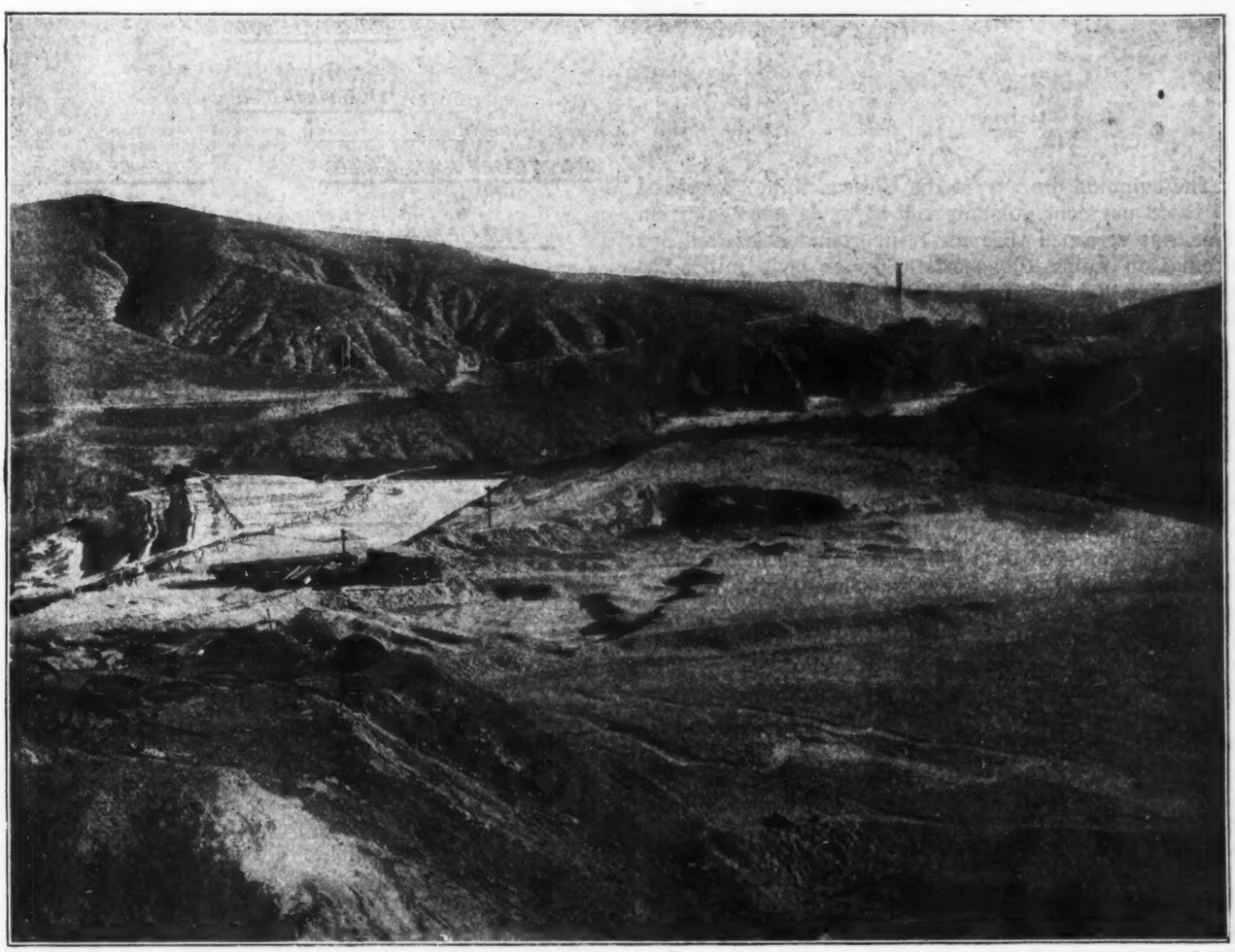
Boston, Mass., March 9, 1920.

Sulphatizing Roasting of Basic Mill Tailings

Method Developed by Shannon Copper Co., Clifton, Ariz., Followed by Precipitation on Iron, Allowed 1 Per Cent Material To Be Treated at a Cost of 13c. Per Pound of Copper Produced

BY WALTER L. MAXSON
Research Engineer, New Jersey Zinc Co., Palmerton, Pa.
Written exclusively for *Engineering and Mining Journal*

LOW-GRADE copper ores too basic for direct acid leaching offer a wide field for metallurgical investigation. Among other processes, sulphatization and direct water leaching has been the object of a great deal of experimental work. The tests of the Shannon Copper Co. at Clifton, Ariz., were noteworthy, inasmuch as this process was developed to the stage where a plant of 150 tons' capacity was in operation for over a year. The pioneer work was carried out by F. S. Schimerka, and included tests of long duration, using multiple-hearth furnaces three and nine feet in diameter.



TAILING DUMP OF THE SHANNON COPPER CO EXCAVATING EQUIPMENT SHOWN IN CENTER

The developed process consisted of a slow oxidizing roast, using iron pyrite as an addition agent. The copper sulphate was leached from the calcine in a Dorr continuous counter-current washing system, and the liquors were precipitated on scrap iron.

Over a million tons of tailings averaging 1 per cent copper were available. These lay in a canyon adjacent to the mill, the surface of the tailing pond being approximately three hundred feet below the leaching-plant bins. The tailings were excavated by a drag scraper, operated by a steam hoist, with particular care to cut the sand and slime strata in such a way as to give a well-mixed feed. The scraper dumped into the boot of a bucket elevator which discharged into side-dump railway cars. This equipment required an operating crew of three men and had a capacity of approximately 135 tons a day.

Loaded cars were switched to the storage bins, the latter of three hundred tons' capacity. The feed passed a 1-in. round-bar grizzly, better to mix the sand and slime and to remove foreign material. The feed hoppers directly beneath the grizzlies were of five tons' capacity, and had a cross-section area of nine square feet. The feed column rested on a steel apron conveyor, no trouble being experienced from the moist charge

hanging up in the hoppers. The apron conveyors were replaced by 30-in. rubber conveyor belts driven by 17-in. pulleys and supported by closely spaced rollers beneath the hopper opening. This arrangement gave a steady stream of feed, which was absolutely necessary to insure even mixing of the tailings and the sulphide ore.

The Shannon ores were graded as oxide and sulphide. The former occurred in a gangue of altered limestone and decomposed porphyry; the latter was mainly chalcocite, with iron pyrite in porphyry gangue. Some cuprite and native copper was also present. Mill tailings were used for experimental work. The following analysis represents the average percentage composition for one year: Cu, 1.07; SiO_2, 61.88; Fe, 8.98; S, 0.98; Al_2O_3, 13.32; CaO, 2.57; MgO, 2.18; Zn, trace; Mn, trace.

The distribution of the copper is shown by a typical screen analysis as follows:

TABLE I. DISTRIBUTION OF COPPER IN VARIOUS SIZES

Grams	Mesh	Total Cu, Per Cent	Oxide Cu, Per Cent	Per Cent Total Cu as Oxide
11.7	on 28	1.12	0.66	59.0
35.1	28 to 48	0.98	0.62	63.3
17.9	48 to 65	0.76	0.54	71.0
12.7	65 to 100	0.70	0.56	80.0
8.3	100 to 150	0.83	0.64	77.1
5.9	150 to 200	0.84	0.70	83.4
8.4	Minus 200	1.74	1.44	82.8
100.0	Total....	0.96	0.67	69.8

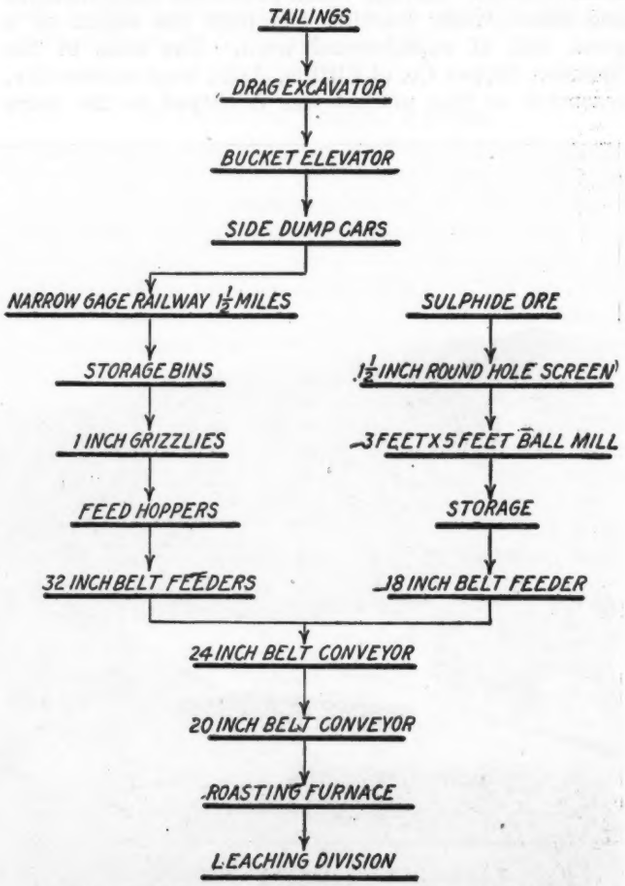
The sulphide ore (from the Gleeson mine) averaged 45 to 48 per cent sulphur and 42 to 44 per cent iron. This was screened through 1½-in. round holes and dry ground to minus-100 mesh (65 per cent minus-200 mesh) in a 3 x 5-ft. ball mill. The ground ore was fed to the conveyor system by an 18-in. belt feeder. An average of 1.5 tons was used daily.

The roaster merits particular attention, as it embodied several novel features. Of the McDougall type, 24 ft. inside diameter, it had ten roasting hearths and one air pre-heating hearth, the effective hearth area being 2,580 sq.ft. Two fire boxes, 180 deg. apart, delivered pre-heated air to the ninth hearth. The walls were double, the inner wall, 13 in. thick, consisting of red brick separated by a 4-in. air space from the outer wall, 8 in. thick, of hollow tile. The hearths were of reinforced concrete, except the tenth, which was composed of cast-iron plates, and all the hearths were supported by steel beams carried on rollers bearing on plates set in the inner wall. No indication of failure of either hearths or beams was noticeable after a year's service. The usual sand-seal joint was used around the central shaft on outside drop hearths, and the center drop hearths had a 2-in. expansion joint around the periphery, sealed by cast-iron shiplap plates loosely strapped together. These made a satisfactory seal.

The main shaft of the furnace was an 18-in. (outside diameter) mild steel pipe 1 in. thick. Two stubs were welded to the shaft on each hearth to serve as supports for the 5-in. extra-heavy pipe used as rabble arms. The top hearth carried four arms to equalize the loading caused by damp feed. The entire weight of the shaft was carried by steel ball bearings, later replaced by a step bearing made up of a fiber disk between two hardened steel disks. Horizontal thrust was taken by collars at the top and bottom. Rabbles of sheet steel were used on all hearths except numbers one and two, where special abrasion-resisting metal was used.

The roaster operated under induced draft produced by a 42-in. fan. The path of the air was downward between the walls, beneath the cast-iron tenth hearth, against which it was baffled, and around the sides of the fire boxes to meet the oil flame from the burner. The heated air passed to the ninth hearth, upward through the roaster, and was exhausted vertically from the top hearth and downcast into a dust chamber of hollow tile, from which it was drawn by the fan. The calcine discharged from a self-sealing hopper into two 30-ft. screw conveyors leading to the leaching section. These conveyors were replaced by a 26-in. revolving pipe, which was later replaced by a launder delivering directly into a leaching drum. Operating with only one fire box was also found possible, thus effecting a considerable saving in fuel.

The conditions tending to a maximum conversion of copper to copper sulphate are: Copper in the form of



FLOW SHEET OF RECOVERING AND ROASTING OPERATIONS

oxide, energetic catalyzers (as ferric iron and silica) for the oxidation of sulphur dioxide, and such concentration of sulphur trioxide in contact with the ore and the catalyzers as will give sulphatization of the oxide. In general, copper sulphate may be formed through the following reactions in the presence of iron pyrite and catalytic agents:

I. $CuCO_3$, $Cu(OH)_2$ + heat = $2CuO + CO_2 + H_2O$.

II. $CuSiO_3$, $2H_2O$ + heat = $CuO + SiO_2 + 2H_2O$.

III. $2CuS$ + heat + O_2 = $Cu_2S + SO_2$ above 357 deg. C. $2Cu_2S + 5O_2 = 2CuO + 2CuSO_4$ below 500 deg. C. $Cu_2S + 2O_2 = 2CuO + SO_2$ above 500 deg. C.

IV. $4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2$.

Intermediate products may be: $Fe_2O_3.SO_3 = Fe_2O_3 + SO_3$ above 530 deg. C. $4FeSo_4 + O_2 = 2Fe_2O_3.2SO_3$ above 480 deg. C. $Fe_2(SO_4)_3 = Fe_2O_3 + 3SO_3$ between 492 and 560 deg. C.

V. $Fe_2O_3.SO_3 = Fe_2O_3 + SO_3$ above 530 deg. C. CuO

$+ SO_3 = CuSO_4$. $3CuO + Fe_2(SO_4)_3 = Fe_2O_3 + 3CuSO_4$.

VI. $3CuFeS_2 + \text{heat} + 9O_2 = Cu_2S + 3FeSO_4 + CuSO_4 + SO_2$. $4Cu_2S + 4FeSO_4 + 11O_2 = 8CuSO_4 + 2Fe_2O_3$ above 590 deg. C.

Magnesium, lime, zinc, and manganese may also be sulphatized. Dissociation of copper sulphate takes place above 650 deg. C., mainly as follows:

$$2CuSO_4 = CuO.CuSO_4 + SO_2$$
$$CuO.CuSO_4 + SO_2 = 2CuO + 2SO_2$$

With a given ore and roaster it is absolutely necessary to establish certain empirical conditions in order to maintain a high average conversion. The following table of operating data covers the conditions as developed for this particular roaster and ore:

TABLE II. OPERATING DATA AT SHANNON PLANT

Feed average, 15 per cent. moisture
Tonnage, 110 dry tons per day
Sulphide ore, 1½ tons daily
Fuel oil, 5 gal. per ton
Temperature, 521 deg. C. (air entering ninth hearth)
Roaster speed, 1 r.p.m.
Treatment time, 8 hours
Depth of charge, 2.92 in.
Hearth area, 2,580 sq.ft. (23.4 sq.ft. per ton per day)
Pre-heated air, 133 deg. C. (by radiation)
Gas volume, 6,800 cu.ft. per min. at 191 deg. C. = 93,700 cu.ft. per ton
SO_2 in flue gas, less than 0.10 per cent
Gas velocity, maximum 4.4 ft. per sec., fire box opening ninth hearth; minimum 0.31 ft. per sec. in dust chamber, 1.48 ft. per sec. in upcast flue from top hearth
Flue dust, 0.8 per cent of total tonnage
Temperature of calcine, 470 deg. C.

Average Results

Total Cu in feed,	0.85	to 1.00	per cent
Water soluble,	55	to 62	per cent
Sulphatization,	88	to 97	per cent

The above data were determined mainly as a result of the following tests:

Rate of Feed—The roaster was designed to treat 150 tons per day, but this was limited to 110 tons by the leaching capacity and by the increase of moisture content in the tailings. A maximum of 176 dry tons was treated, although this was sandy material carrying only 7 per cent moisture.

SIDE VIEW OF TAILING DUMP FROM SLAG DUMP LEVEL

Amount of Sulphur—The sulphur added to the feed was an amount such that the percentage of copper plus 0.4 equaled the percentage of sulphur. Above this amount the sulphatization decreased, the temperature of the calcine exceeded (at times) the decomposition temperature of copper sulphate, and control was difficult. With decreasing amounts of sulphur the sulphatization was high (98 per cent), but there was less ferric iron in the calcine, and the water-soluble content was low.

Volume of Air Drawn Over the Charge—The limiting factor here is the ore-fuel ratio, which bears a direct relation to the volume of air. The air used was a minimum to give best average results. For a given set of conditions the volume was decreased until maximum sulphatization was obtained. In general, when treating slimes (with higher copper sulphide content) a greater volume of air was necessary.

Rate of Rabbling, Depth of Charge, and Treatment Time—These are interdependent for a given tonnage. Operating at one revolution in 75 sec., with a depth of bed approximately 3¾ in., and with a treatment time of 10 hours, extractions and sulphatization were low. There

TABLE III. TEST NO. 1. FEED 7 PER CENT H_2O. TOTAL COPPER 0.98 PER CENT; OXIDE COPPER 0.54 PER CENT

Building temperature, 31 deg. C.
Gas volume, 6,890 cu.ft. per min.
Pre-heated air, 110 deg. C.
Pre-heated gases, 482 deg. C.
Flue gas, 160 deg. C.

Hearth No.	Gas Temp., Deg. C.	Calcine Temp., Deg. C.	Water Sol. Cu, Per Cent	Oxide Cu, Per Cent
2	193	120	0.9	0.52
4	263	230	0.3	0.56
6	409	411	27.2	0.67
7	434	493	54.7	0.72
8	430	519	56.5	0.89
10	385	443	62.3	0.91

Calcine from floor No. 4 showed clean pyrite.
Calcine from floors Nos. 6 and 7 showed no pyrite; SO_2 fumes strong.
Calcine from floors Nos. 8 and 10, little SO_2.
It was apparent that evolution of sulphur dioxide was well under way on hearth No. 6 with a greater part of the copper sulphate formed between No. 4 and No. 7.

TEST NO. 2

Feed 15 per cent H_2O. Total Cu, 0.81 per cent; oxide Cu, 0.43.
Building temperature, 35 deg. C.
Gas volume, 6,890 cu.ft. per min.
Pre-heated air, 133 deg. C.
Pre-heated gases, 521 deg. C.
Flue gas, 191 deg. C.

Hearth No.	Gas Temp Deg. C.	Calcine Temp., Deg. C.	Water Sol. Cu, Per Cent	Oxide Cu, Per Cent
2	211	2% H_2O	....	0.39
4	296	258 deg. C.	0.2	0.42
6	468	549	46.2	0.47
7	521	561	57.3	0.52
8	510	502	59.1	0.61
10	481	473	65.3	0.69

Calcine from hearth No. 4 showed pyrite undecomposed.
Calcine from hearth No. 6 evolved SO_2 strongly and showed some ferric iron.
Calcine from hearth No. 7 showed increased amount of ferric iron.
Calcine from hearth Nos. 8 and 10, practically no SO_2 evolved.

TEST NO. 3

Feed 13 per cent H_2O. Total Cu, 0.92 per cent; oxide Cu, 0.61.
Building temperature, 28 deg. C.
Gas volume, 6,800 cu.ft. per min.
Pre-heated air, 146 deg. C.
Pre-heated gases, 565 deg. C.
Flue gases, 242 deg. C.

Hearth No.	Gas Temp., Deg. C.	Calcine Temp., Deg. C.	Water Sol. Cu, Per Cent	Oxide Cu, Per Cent
2	227	168	....	....
4	361	380	7.4	....
6	505	621	61.3	0.66
7	570	604	69.4	0.68
8	563	591	64.3	0.70
10	503	490	62.4	0.72

Calcine from hearth No. 2 showed undecomposed pyrite.
Calcine from hearth No. 4, strong evolution of SO_2.
Calcine from hearth No. 7, slight evolution of SO_2.
Ferric iron abundant on hearth Nos. 6, 7, 8, 9, 10.

was apparently no ferric iron in the calcines, and some magnetic iron could be separated. The roaster was overloaded. These tests were repeated with an increased volume of air, giving increased extraction and sulphatization, but with a high fuel ratio. Operating at one revolution in 45 sec., with a depth of bed approximately 1¾ in. (80 ton per day feed), and a treatment time of 6 hours, the extraction was a little below normal. Sulphatization was high, as was the ferric iron content, but the calcine was decidedly cooler for a given operating temperature.

Operating Temperatures—The tests shown in Table III, each covering such a period of time as to give comparable results, were deciding factors in establishing operating temperatures.

Apparently some basic copper sulphate was forming between the eighth and tenth hearths.

Discussion of Tests—The conclusions drawn from these tests were, that to obtain maximum conversion to copper sulphate it would be desirable to distribute the reaction zone over several hearths, to take full advantage of the slower evolution of sulphur dioxide in the presence of catalyzing agents. Heating rapidly to reaction temperature appeared to give a maximum concentration of sulphur dioxide higher in the furnace, and the over-all conversion was lower. The recovery of sulphide copper was somewhat higher at the higher temperatures, but there was some tendency to form basic sulphates. When the temperature was low, the over-all efficiency of the roaster was low, damp feed being discharged to the third hearth, and even though the evolution of SO_2 was distributed over several hearths, the ore apparently had not reached such a temperature as would allow active reaction.

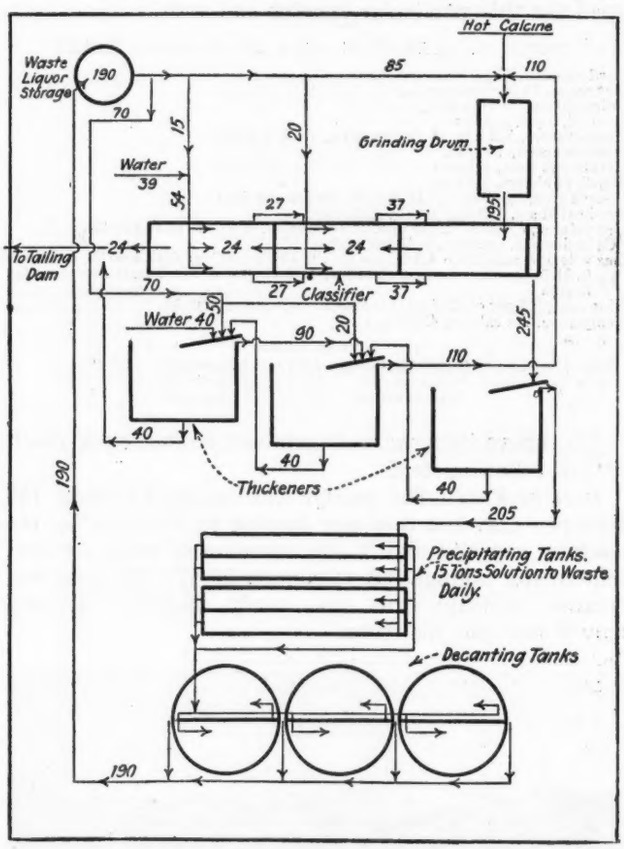
The ignition temperature of pyrite is given as 325 deg. C. and that of chalcocite as 430 deg. C. The decomposition temperature of copper sulphate is 650 deg. C., and of iron sulphate, 590 deg. C. Thus it would appear that maximum conversion might be obtained between 590 deg. and 650 deg. However, with a roaster of this type, if operated over this temperature range, the reaction zone is high in the roaster, and the sulphur dioxide concentration is high on the upper hearths where the ore has not had the benefit of long contact with the oxidizing atmosphere. If, however, the gases in the roaster might be reversed and down-drafted, then a quick heating up to reaction temperature would give an opportunity to utilize the sulphur dioxide as it passed over the well-heated ore on the lower hearths. In this connection the practice of using pressure on the furnace might be advocated, to eliminate the possibility of drawing in false air. A furnace of this same general type, with a downward passage of pre-heated air, operating under pressure, would offer interesting possibilities.

The ore-fuel ratio obtained was satisfactory, and the pre-heating device was a distinct saving in thermal efficiency. It would be of interest to compare a roaster of this type with a well-insulated steel-shell roaster of the Wedge type, using a heat interchanging system as a means of pre-heating the air.

Leaching was carried on in a Dorr continuous counter-current washing system. The equipment consisted of a wooden-lined pebble mill 4 ft. in diameter by 5 ft. long, an acid-proof Dorr classifier 27 in. wide by 41 in. long, of three decks; three acid-proof thickeners 12 x 18 ft. in diameter, three 4-in. acid-proof diaphragm pumps for handling slime pulp, and two acid-proof centrifugal pumps for handling liquors.

The separation of the metal depends upon the complete solution of the copper sulphate and dilution of the resulting pulps. Originally, the calcine was mixed with weak solution in a concrete box, the pulp discharging to the first deck of the classifier. The slimes separated from the sands by the classifier passed to the thickening system, together with the copper-bearing solution washed from the sands. The design was based upon the assumption that the copper sulphate dissolved almost immediately after the calcine was pulped. Considerable experimental work showed that solution was slow up to 45 min., but if the calcine was ground to pass 10 mesh to break up agglomerated particles, the solution time was reduced to 4 min.

As a result of these tests a wooden-lined drum was installed for grinding the calcine under water with pebbles. The speed of the classifier was also altered to 10 strokes per min., as against 12 formerly. This increased the treatment time in the classifier from 4 to 6 min., and with approximately 2 min. in the grinding drum, the loss of soluble copper was reduced from 20 to 7 per cent. This represented an increase in recovery



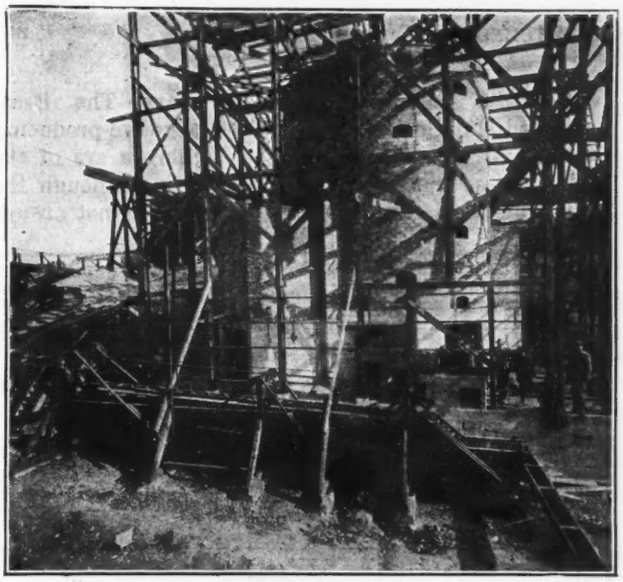
FLOW SHEET OF LEACHING PLANT

of 2.4 lb. per ton, based upon 0.5 per cent soluble copper in the calcine. The sands were dewatered to 25 per cent moisture on each deck of the classifier. The discharged sands averaged less than 11 per cent of minus-100 mesh material. The sand tailings were reduced to as low as 0.015 per cent soluble copper for a period covering several days.

Shannon slime, calcined, required 7 sq.ft. of settling area per ton at 64 deg. C., and 17 sq.ft. per ton at 27 deg. C. The temperature obtainable at the first thickener depended upon the amount of solution advanced from the classifier. To maintain a low solid content in the liquors to the precipitation tanks, it was necessary to limit the amount of wash water. This, in turn, limited the separation of copper by dilution and increased the loss in tailings. The original estimate of 20 per cent slime in the tailing dump was about 10 per cent low.

Clear liquors for precipitation were maintained until the installation of the grinding drum permitted of nearly complete separation of all of the slimes. On a

basis of 27 deg. C. as the operating temperature of the first thickener, a 28-ft. thickener would have been necessary to handle this slime tonnage. This matter was under consideration when the plant ceased operations in January, 1919. The slimes were easily thickened to 50 per cent solids by controlling the diaphragm pumps.



ROASTER DURING CONSTRUCTION PERIOD. FIREBOXES AT LEFT AND RIGHT, CONCRETE LAUNDERS FOR SCREW CONVEYORS, AND DORR CLASSIFIER

The slime discharged to waste averaged 0.02 per cent soluble copper. The sand and slime tailings were combined and discharged by launders to a tailing dam in the canyon below the plant.

Small-scale leaching tests made on the sands and slimes combined gave an increased extraction of 10.45 per cent copper, with a consumption of 3.62 grams of 3 per cent sulphuric acid per gram of copper. Tailings before calcination require approximately 8½ grams of sulphuric acid per gram of copper.

Fresh water was added at the third thickener and at the last deck of the classifier. Increased extraction of copper from basic salts and oxides in the calcine was obtained by using as wash water the residual liquors from precipitation, carrying some ferric iron. Possible reactions are:

$$Fe_2O_3.3SO_3 + CuO = CuSO_4 + Fe_2O_3.2SO_3$$

$$Fe_2(SO_4)_3 + CuS + 3O + H_2O = CuSO_4 + 2FeSO_4 + H_2SO_4$$

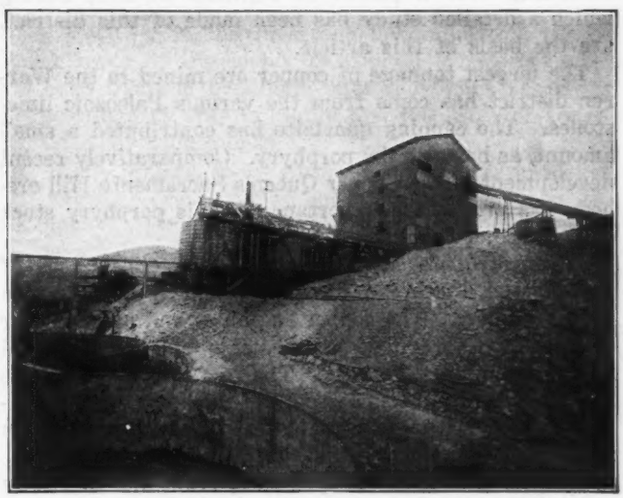
$$Fe_2(SO_4)_3 + Cu_2S = CuSO_4 + 2FeSO_4 + CuS$$

The precipitating system consisted of tanks with false slatted bottoms, upon which the iron rested. The true bottoms sloped to the discharge gates, and the precipitate was discharged into launders by washing it from the iron with water. The precipitate launders led to decanting tanks and drying platforms, where the cement copper was air dried prior to shipment. The tank arrangement was very flexible and eliminated rehandling of iron. It required six-man-hours to clean one tank. All scrap iron was handled by hand. After precipitation, the residual liquors were collected by a system of launders and pumped to a storage tank, from which they ran by gravity, for washing calcine.

An average of 205 tons of solution was precipitated per day, yielding a pregnant liquor of 0.3 per cent copper. This was precipitated on iron to an average of 30 parts per million, requiring 1.6 lb. of scrap iron per pound of copper. The precipitate obtained averaged as follows for twenty-four shipments: Copper, 60.4 per cent; moisture, 35.4 per cent; iron compounds, 7.9; metallic iron, 0.8; sulphur, 1.4; insoluble, 10.4.

The free acid in the strong liquors was less than 0.005 per cent, and the flow of the strong liquors was changed daily so as to pass them over freshly cleaned iron. Fine scrap iron was used for the strongest liquors. Precipitate from these first tanks ran as high as 74 per cent copper. Tests were made on improving the average grade of precipitate by washing it on a copper screen. This yielded a product averaging 74.5 per cent of copper, the separated product being mainly iron and silica.

The operating figures for the period from July, 1918, to January, 1919, were as follows: Operating days, 139.13; tons treated, 12,599; copper delivered, lb., 169,621; pounds per ton, 13.46; extraction, per cent, 67.31.



THICKENER AND ROASTER BUILDING

Expense of excavating, roasting and leaching 110 tons daily, yielding 13.46 lb. copper per ton, or 44,400 lb. per 30-day month:

Power, 77 hp. at $9.45 per hp.-month		$727.00
Insurance, depreciation, analysis and supplies	$400.00	
Switching, 120 cars at $2.50	300.00	
Fuel oil, 5 gal. 14 deg. per ton, at $2.76	1,085.00	
Sulphide ore, 45 tons at $7.78	350.00	
Scrap iron, 1.6 lb. per lb. copper at 1c. per lb.	711.00	
		$2,846.00
Labor		
Roasting and leaching (six men)	851.40	
Excavating (three men)	398.70	
General (five men)	604.50	
		1,854.60
Miscellaneous		
Supplies	50.00	
Repairs and replacements	360.00	
		410.00
Total		$5,837.60
Cost per lb. of copper reduced		13.16c.

Note: Wage scale is based on 34c. copper.

It would be difficult to compare the operations of a unit of this size with those of much greater magnitude, such as the plants at Ajo and Anaconda. But, at the same time, if the true nature of the Shannon oxidized ores be given consideration, the results obtained were not without significance.

The full possibilities of sulphatizing, roasting and leaching (either by water or acid) have not been fully realized, and the future affords opportunities for a large amount of profitable development.

Ore Deposition in the Warren District, Arizona

Geological Factors, Including Formation, Faults, Fractures, Crushed Zones, Bedding, and Porphyry Intrusions, Have Influenced the Position, Extent, and Richness Of Copper Deposits in This Region

BY GRAHAM JOHN MITCHELL
Written exclusively for *Engineering and Mining Journal*

THE copper deposits of the Warren district, Bisbee, Ariz., present a field for varied and interesting geological investigation. The work of F. L. Ransome and others has covered the area in an able manner. However, as development of known orebodies and prospecting in new ground progresses, details of geological structure and mode of occurrence of ore are disclosed which bear recording. Observations extending over a period of eighteen months, during which a detailed study has been made of this district, are the basis of this article.

The largest tonnage of copper ore mined in the Warren district has come from the various Paleozoic limestones. The capping quartzite has contributed a small amount, as has also the porphyry. Comparatively recent development of the Copper Queen's Sacramento Hill orebody has proved the importance of this porphyry stock as a source of copper.

Abrigo (Cambrian) Limestone—The upper beds of the Abrigo limestone have produced a considerable tonnage of ore. The copper sulphides and oxides occur bedded with irregular replacements along faults and fractures cutting the beds. The less impure limestone members are the most susceptible to copper mineralization. Stratification and lamination of the rocks have in many instances been preserved.

Capping Quartzite—A quartzite, from one to twelve feet thick, is the only stratigraphic representative of the geological time interval between the Cambrian (Abrigo limestone) and the Devonian (Martin limestone) in the district. The varying thickness of this member, and the fact that sometimes beds in the upper Abrigo near the quartzite horizon have been silicified so as to simulate true quartzite, add uncertainty to the use of this formation as an index bed. However, it is possible that, by a petrographic study of the quartzite and silicified limestone, criteria will be found which will aid in their differentiation.

The quartzite has acted as a host for mineral deposition, sometimes being entirely replaced by pyrite and chalcopyrite. Partial replacement of the quartzite by pyrite is a common feature. Native copper, cementing the quartz grains and filling fractures in the rock, has been noted in a number of instances.

Martin (Devonian) Limestone—The Martin limestone is one of the main productive horizons, having contributed a large proportion of the ore thus far mined. The deposits form irregular replacements, conforming more or less to the bedding in the limestone, their greatest dimensions being in or near the horizontal plane. Deposition in this formation has also taken place along faults, fractures, and sheared zones, the deposits taking the form of irregular pipes or chimneys. The lower and upper portions of the Martin formation are the most extensively mineralized. The copper minerals include bornite, chalcopyrite, covellite, chalcocite (both steely and sooty), malachite, cuprite, azurite, native copper, and chrysocolla.

Escabrosa (Mississippian) Limestone—The Escabrosa and Martin limestones are the large ore-producing formations. The deposits in the Escabrosa are of the same type as those found in the Martin, although the more massive limestone of the former does not always

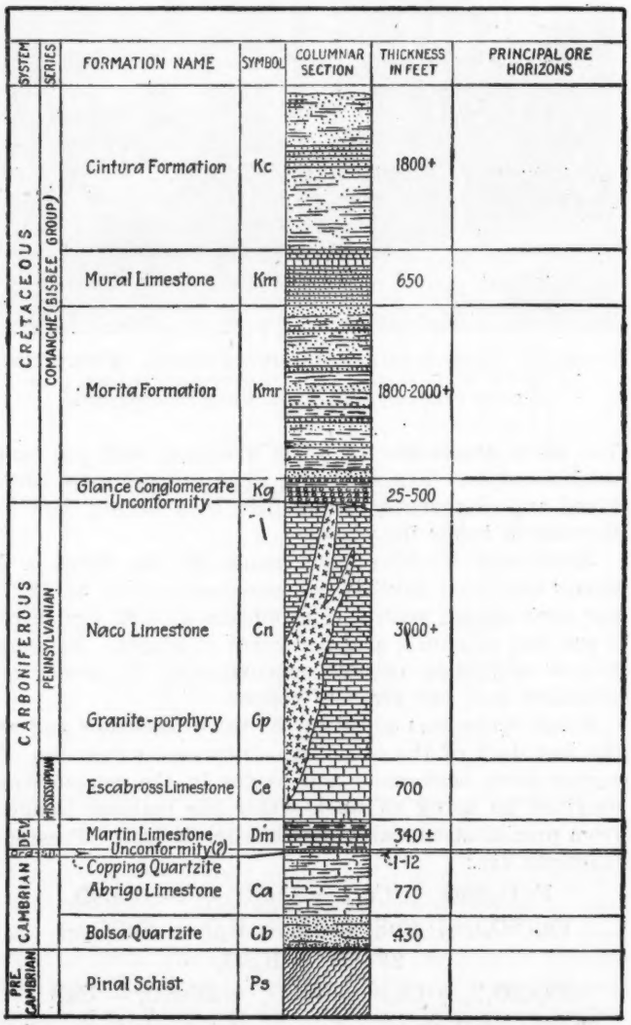


FIG. 1. COLUMNAR SECTION OF THE SEDIMENTARY ROCKS OF THE BISBEE QUADRANGLE. MODIFICATION OF SECTION BY F. L. RANSOME, U. S. G. S. FOLIO NO. 112. CROSSES INDICATE PRINCIPAL ORE HORIZONS

leave traces of bedding in the ore, as is so often the case with the Martin. The blanket-like deposits are of varying dimensions, but here also, as in the case of ore in the Martin, the greatest extent is in or near the horizontal. Deposits are also found in the Escabrosa along closely spaced faults and fractures where the rock has been crushed and broken, thus offering openings for the copper-bearing solutions. Orebodies of this type generally stand at steep angles and pinch along the strike and dip of the original faulting. The lower and middle Escabrosa are particularly favorable horizons.

Naco (Pennsylvania) Limestone—In general, the Naco limestone is thinner bedded and finer grained than the Escabrosa. However, these features cannot be used safely as criteria for differentiating the formations underground, as beds of the same lithological character occur in both. The safest indicators, therefore, are the fossils, though it requires time and patience to find them underground where weathering has not had the opportunity to make the shell outlines distinct.

Ore in the Naco takes the form of irregularly bedded deposits with stringers, following fractures and faults, cutting the bedding. In form the orebodies differ little from those in the Escabrosa and Martin limestones, but they are much less extensive. Beds in the lower half have been more productive.

Structural Factors

Structural factors which are responsible in a major way for ore deposition in the district include faults, fractures, crushed zones, and bedding. Under faults are included all breaks in the rocks along which there is evidence of movement having taken place. In many instances strong mineralized fractures cut orebodies, and probably are faults, though all indications of movement are obliterated by mineralization and subsequent alteration.

Faults which antedate the period of primary mineral deposition have served as channels of access for the copper-depositing solutions, the mineral-bearing vapors having traveled along such openings until conditions favorable for deposition were encountered. Favorable conditions so far as the evidence indicates occurred at the intersection of faults or fault zones, also in crushed zones and along fractures. The faults themselves are sometimes mineralized, the gouge and breccia carrying a good copper content, but the amount of such copper is generally too small to warrant drifting along the break unless the drift is being driven to cut favorable areas ahead.

Faults have also served to conduct mineral-bearing solutions to points where they have encountered beds susceptible to replacement. Another class of faults are those which have originated after the period of primary mineralization and which frequently displace orebodies. Such displacements are generally known in mining as post-mineral faults. In dealing with this class, detailed stratigraphic study will in most cases prove the post-mineral character and also the amount of displacement, thus aiding in the location of faulted portions of ore.

Fractures refer to those breaks in the rocks along which there has been no movement. The influence of fractures upon the course of mineralizing solutions has been similar to that exerted by the faults. In the case of fracturing, however, it is common to have a concentration of such fractures passing through an area and forming a zone of more or less parallel openings. Such zones, although not always sufficiently mineralized to make ore, are, however, among the most promising areas for prospecting. Some of the largest orebodies in the district are situated along fracture zones.

Fracturing of primary bodies of pyrite carrying small amounts of chalcopyrite and bornite is an important factor in producing workable ore. Such fracturing has allowed descending water to effect a concentration of the primary copper in the form of sooty chalcocite, which coats and occasionally completely replaces the pyrite. A black earthy substance sometimes occurs with these enriched bodies of pyrite, and resembles sooty chalcocite. When tested, such material gives strong indications of manganese, and is undoubtedly impure pyrolusite. Replacement of the limestone beds inclosing the primary pyritic material by secondary chalcocite takes place in some instances, in this manner increasing the extent of the orebody.

Disseminated pyrite in fractured porphyry has been enriched by chalcocite, the pyrite in the highly altered rock being coated with chalcocite. In some cases the pyrite is completely replaced by the copper sulphide.

Zones of crushed rock occurring along faults are sometimes the loci of rich orebodies. Such zones generally stand at steep angles, the ore having its greatest extent along the strike and dip of the faulting. Both primary and secondary copper minerals are found in these zones. The best examples of this mode of occurrence are found in the "oxide orebodies" of cuprite, chalcocite, native copper, malachite and azurite.

Bedding in the limestone has influenced the course followed by the copper solutions. Where the solutions have followed bedding planes they have reached these openings by way of faults and fractures or zones produced by such breaks.

The igneous rocks responsible for the copper-bearing solutions are classified under the general name of porphyry. For practical purposes this classification is acceptable, although petrographic study would show types ranging from an acidic to a medium basic rock. A general grouping can be made megascopically into rocks of fine texture, with few or no ferromanganesian minerals, scattered quartz phenocrysts, and abundant orthoclases; and of a much coarser texture with a strong development of biotite, hornblende, quartz, and feldspar. Between the two types are gradations which require optical study for proper differentiation.

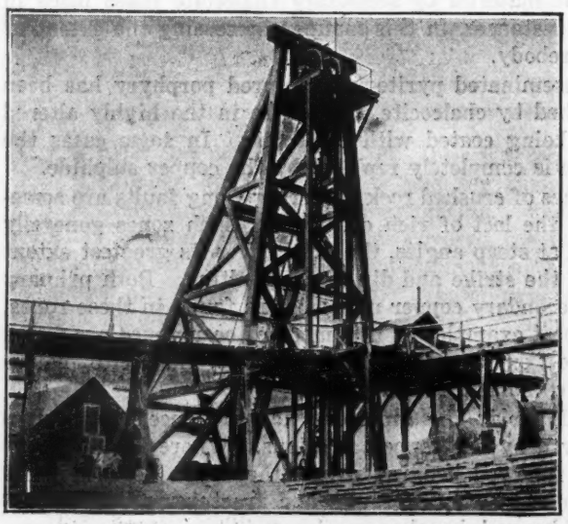
The Sacramento Hill stock and the many porphyry intrusions associated with other orebodies represent offshoots from a parent magmatic mass. Such intrusions probably were not simultaneous, but extended over a considerable period in Pre-Cretaceous time. The placing of responsibility for the copper mineralization upon porphyry is conclusively substantiated by the evidence afforded in the Sacramento Hill orebody and at various other places in the district.

Motor-Gasoline Situation

In the "Monthly Reports of Investigations" for February, 1920, N. A. C. Smith sums up the motor-gasoline situation in the following:

"The motor-fuel problem must be considered in two aspects: In the immediate future, it is likely that there will be little change in the character of the gasoline sold throughout the United States. Surveys made by the Bureau show that the change in volatility of motor gasoline from April, 1919, to January, 1920, is so slight as to be negligible. The more distant future is, of course, problematical, but it is estimated that, all sources considered, there will be a sufficient supply of motor fuel, although it is probable that it will be more expensive in proportion to the general run of prices than it is today. Some of this fuel can be used as at present, but it will probably be necessary to design new engines to use fuel oil, as it is doubtful if the present gasoline engine and carburetor can be modified for this purpose."

Methods of Ore Handling and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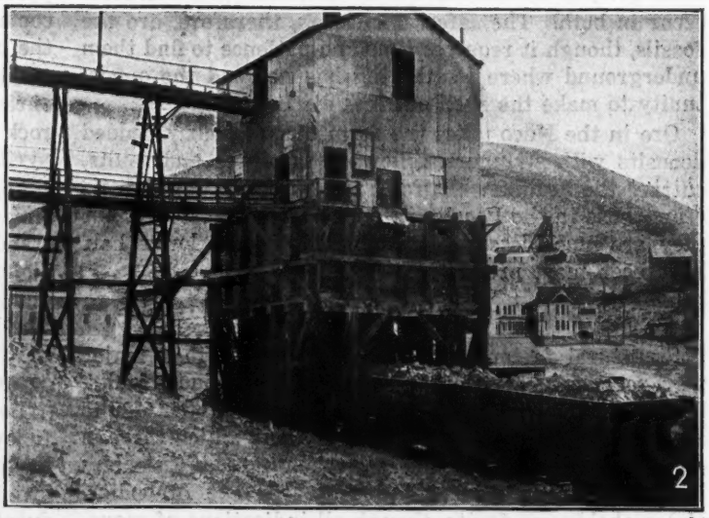
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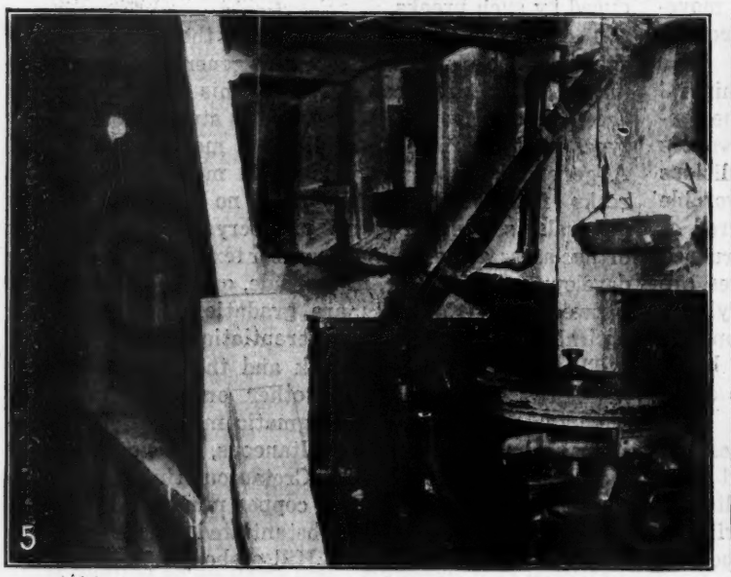
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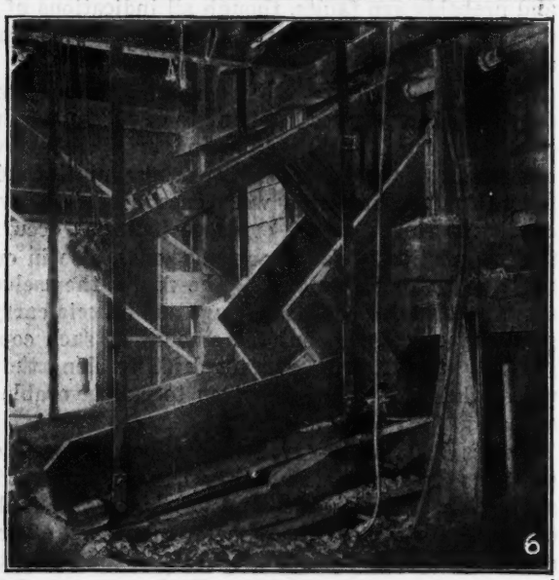
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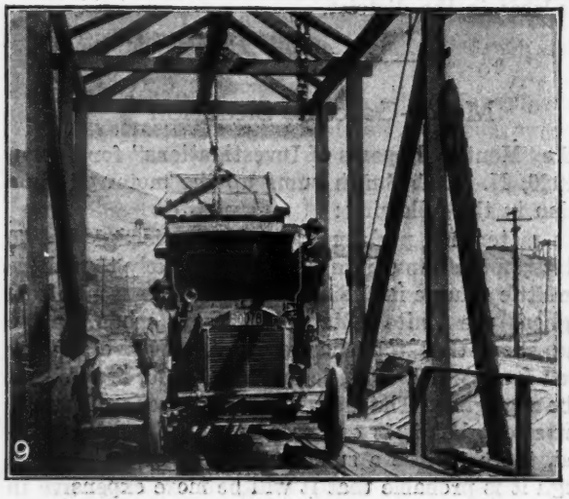
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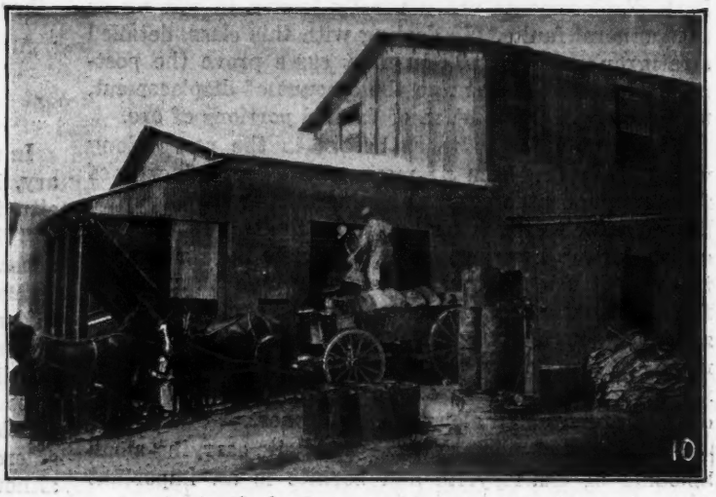
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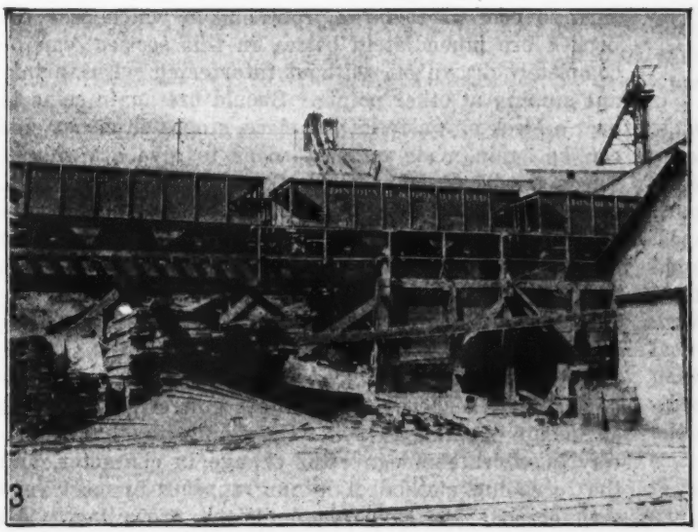
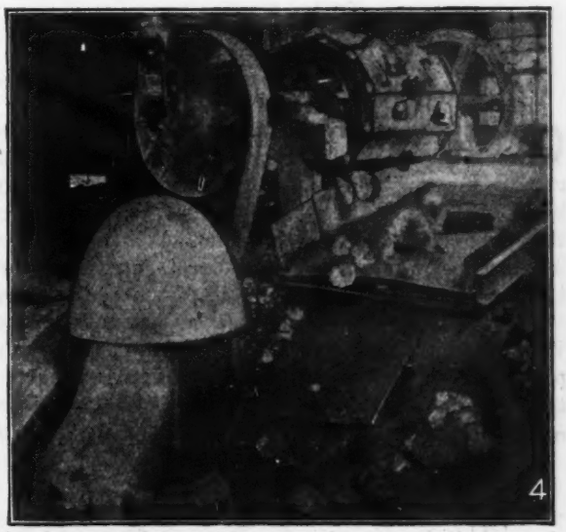
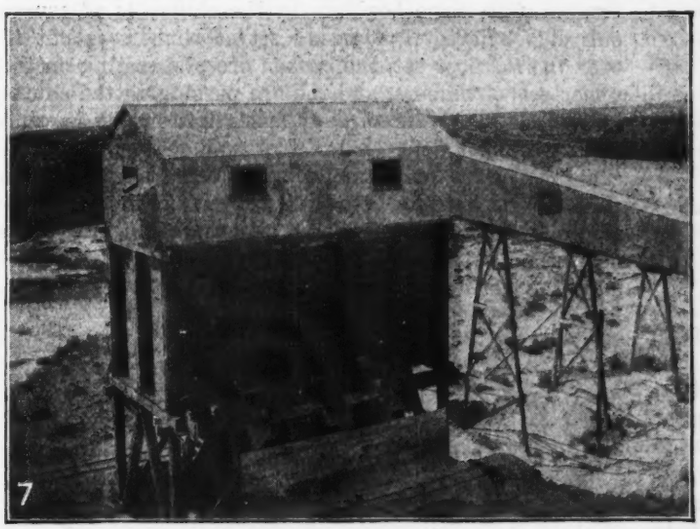
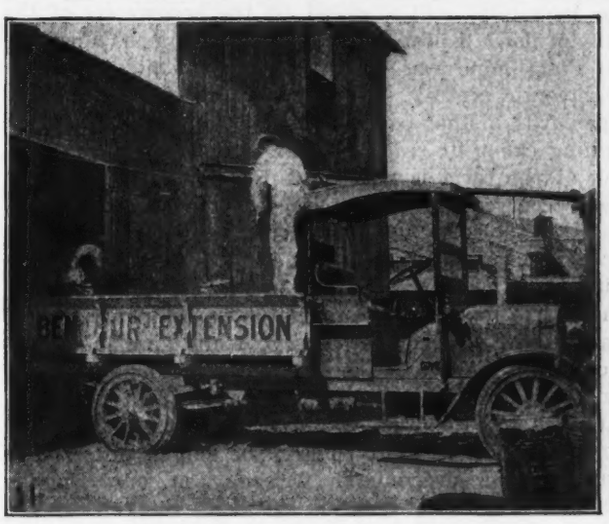
NO. 1. SILVER TOP SHAFT, TONOPAH, NEV. NO. 2. ORE BINS CLOSE TO SILVER TOP SHAFT. 50-TON STEEL ORE CARS FOR TRANSPORTATION TO TONOPAH BELMONT MILL. NO. 3. RECEIVING BINS AT TONOPAH BELMONT MILL. NO. 4. APRON CONVEYOR DISCHARGING INTO A GYRATORY AT THE TONOPAH BELMONT MILL. NO. 5. ELECTRIC LOCOMOTIVE, TONOPAH EXTENSION MINE. UNDERGROUND TRANSPORTATION OF ORE IN TONOPAH MINES IS DONE BY HAND TRAMMING, MULE HAULAGE AND THE ELECTRIC LOCOMOTIVE. NO. 6. FINGER CHUTE GATE, PICKING BELT DISCHARGES INTO A ROCK BREAKER. THE VICTOR SHAFT OF THE TONOPAH EXTENSION.

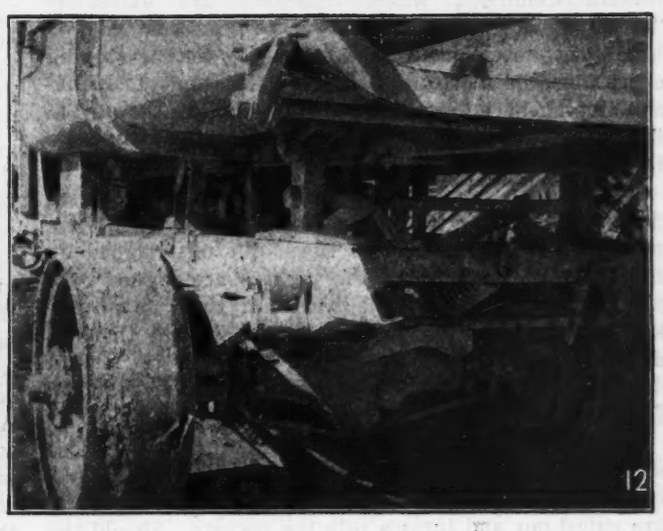
Transportation in the Tonopah District











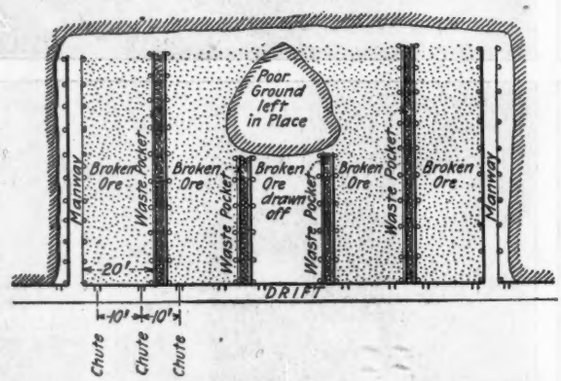
NO. 7. AFTER LEAVING THE ROCK BREAKER, THE ORE IS CONVEYED BY AN INCLINED BELT CONVEYOR TO THE RECEIVING BIN. NO. 8. FROM THE BIN A LOCOMOTIVE AND TRANSFER CAR TAKES THE ORE TO THE MILL. NO. 9. THE ORE IS HAULED IN FIVE-TON AUTO TRUCKS TO THE WEST END AND McNAMARA MILLS. THE DISCHARGING ARRANGEMENT AT THE WEST END MILL. NO. 10. "SWEEPINGS" FROM TAILING DUMPS ARE HAULED TO THE TREATMENT PLANT NEAR THE TONOPAH BELMONT MILL BY TEAMS. NO. 11. SOMETIMES THE SWEEPINGS ARE HAULED BY AUTO TRUCKS. NO. 12. DESERT ROADS ARE HARD ON THE TIRES OF THE FIVE-TON AUTO TRUCKS USED

Notes on Shrinkage Stoping

Advantages of Employing a Modification of the Method and Details as to the Manner Of Its Application

BY DOUGLAS LAY
Written exclusively for the *Engineering and Mining Journal*

ONE of the commonest arguments against shrinkage methods of stoping is that such methods lock up capital, inasmuch as about 50 per cent of the ore broken, being required to fill, is necessarily unavailable, until the whole of the block under attack has been stoped. The cogency of this argument rests upon the assumption that the rate of breaking, in a timbered stope, is as fast as when shrinkage methods are followed. When the latter are applicable, from the purely technical point of view, the rate of breaking is much greater than that possible in a timbered stope. In fact, under ordinary conditions, it is no exaggeration to say that the



ECONOMICAL MODIFICATION OF SHRINKAGE STOPING

rate in the former case is nearly double that in the latter, owing to the heavier blasting possible, the much greater feeling of security, and lack of interruptions experienced by the miners.

An experience of many years in the Slocan district, British Columbia, where oreshoots are extremely "bunchy," and where in many cases the best clue to intelligent development is afforded by actual stoping operations, led me to adopt the modification of shrinkage stoping here described, in order to reap the advantage of the low cost of the latter and at the same time to secure greater elasticity.

The modification consists in carrying up from the sill floor waste pockets at intervals of about 20 ft. These pockets are formed by two rows of stulls, lagged on the inside. The tops of the pockets are lagged over prior to blasting, and the waste in them is always kept a few feet down from the top, so that there is always room for waste after each blast. In the Slocan district, there is usually no difficulty in finding material for these pockets.

After each blast, though nothing in the way of close sorting is attempted, any large pieces of waste resulting either from vein walls or from internal vein filling are culled out and thrown into the pockets. Should the ore be so good, at any time, as to cause a shortage of waste at any point, the pocket at that point is lagged over, and a fresh start made on the floor so formed, the purpose being not to leave an unfilled pocket at the top of the stope, and so to avoid any chance of accident from a man falling down. Furthermore, these pockets divide the stope into sections, so to speak, each of which is to a great extent independent of the other. For instance, the portion between any two pockets may turn so poor as to be unprofitable, in which case the broken ore immediately below, in this section, can be completely drawn off, without interfering with shrinkage stoping at other points. Should ore again come in over a block of waste left in place, stopes on either side can be again made to meet so as to give a V-shaped top to the block, off which broken ore will readily run, as shown in sketch. Incidentally, the waste pockets are of enormous assistance in keeping the vein walls from caving, after all broken ore has been withdrawn. This method of mining presupposes the existence of not less than two manways, one at each end of the block of ground under attack.

In the Slocan district, it is not always possible or advisable to dispense with timber entirely, even when shrinkage stoping is followed, owing to the sudden way in which the vein walls change in character, and the foregoing method of mining appears to meet very satisfactorily the general conditions prevailing. All trouble with large boulders in the chutes is of course entirely obviated if a second set of timbers is put in over the sill floor set, the broken ore pile resting on the upper set of timbers, and the ore passing to the chutes in the sill floor sets through holes left in the lagging over the upper sets, on the foot wall. Large boulders can thus be broken or bulldozed before passing to the chutes. On the other hand, this expedient involves considerable delay and additional expense in opening up a new stope, and occasionally the exigencies of the ore situation hardly permit of it.

Arizona

"Arizona, probably Arizonac in its original form," wrote H. H. Bancroft in his "History of Arizona and New Mexico," "was the native and probably Pima name of the place—of a hill, valley, stream, or some other local feature—just south of the modern boundary, in the mountains still so called, on the headwaters of the stream flowing past Saric, where the famous Planchas de Plata mine was discovered in the middle of the eighteenth century, the name being first known to Spaniards in that connection and being applied to the mining camp, or *real de minas*. The aboriginal meaning of the term is not known, though from the common occurrence in this region of the prefix *ari*, the root *son*, and the termination *ac*, the derivation ought not to escape the reseach of a competent student. Such guesses as are extant (written in 1889), founded on the native tongues, offer only the barest possibility of partial and accidental accuracy; while similar derivations from the Spanish are extremely absurd. The oft-repeated assertion that the original Spanish form was Arizuma has no other foundation than a misprint in some old book or map. The name should properly be written and pronounced Arisona, as our English sound of *z* does not occur in Spanish. Suggestions for the legal name were Arizuma, Arizona, Pimeria, and Gadsonia. Pimeria would have been in some respects more appropriate than Arizona—being of provincial and not merely local application—and quite as euphonious."

Reducing Tungsten Ore

Outline of the Process Used in an English Works—Principal Difficulty Is To Separate Pure Tungstic Oxide From Crude Ore—Metal Then Obtained By Smelting With Reducing Agent

BY T. SINGTON
Manchester, England
Written exclusively for *Engineering and Mining Journal*

THE tungsten industry of Europe, although not large compared with that of the more common metals, is of considerable importance, on account of the use of this metal in high-speed steels. The ores are found in many parts of the world, but usually in such small amounts that they are not treated locally, and the raw material is often transported thousands of miles for treatment. The manner of handling tungsten ores, and converting them into pure tungsten powder, as carried on in English works, is not unlike the method of treatment in other parts of the world, but the subject as a whole is not one which has been widely discussed.

The raw material, as it comes to the reduction works, consists essentially of compounds of tungsten, iron, manganese and oxygen, being frequently associated, also, with tin ores. These supplies, whether coming from the same locality or imported from different countries, may vary in composition considerably. This entails laboratory work, which specially trained experts only can perform, as the processes have to be continually modified to deal with complications, so as to maintain the final output of a constant quality. Over 98 per cent is the degree of purity desired and generally maintained—that is, very little less than pure tungsten; and to maintain it, continuous laboratory supervision is necessary.

A plant for tungsten production should be placed alongside a railway siding, so that the ore can be brought to one end of the works and the tungsten powder removed from the other and conveyed to the various steel works requiring it. Some of the processes give rise to the production of considerable quantities of dust, and it is desirable to inclose the plant producing it, so as not to affect the health of those engaged. It is most important that all of the processes possible should be arranged on the ground-floor level, although some will require to extend through several floors.

The ore, soda, and other materials required are brought alongside the warehouse to a staging level with the tracks, so as to facilitate unloading. The ore is delivered in small cubes, so as to pass through a 1-in. mesh. Assuming that it consists of tungsten oxide and waste materials, eight separate operations are necessary to produce pure tungsten powder. Each operation takes place in a separate department, and the buildings are so planned that the material always moves in one direction. Of these eight operations, no less than six are required to separate the tungsten oxide from the other constituents of the ore. By the other two, the pure or nearly pure tungsten is obtained by the elimination of the oxygen. When ores contain other valuable ingredients, such as tin or bismuth, they are separated by means of magnetic separators, as the wolfram is sufficiently magnetic to enable that to be done.

The first step is to sample and assay the ore, which is then loaded into small trucks and elevated to a series of bins about sixty feet above the ground level. Any ore requiring special treatment is kept separate. The ore in the bins is then transferred to grinding machines and, if necessary, is put through the magnetic separators mentioned above. It is then conveyed to calcining furnaces. A special department is provided for impure or mixed ores which cannot be effectively treated by mechanical and magnetic methods. After roasting, the pure wolfram is conveyed in trucks to bins placed over mixing machines near a supply of soda. The finely ground ore and the soda, in accurately weighed proportions determined by analysis in the laboratory, are then fed into double-arm mixers, and the mixed product is discharged into trucks to be conveyed to the melting furnaces. Scheelite and mixed wolfram—tin slimes, tin residue mixed with small quantities of tungsten ore, as well as residues of other sorts—are treated in a separate plant, so that impure sodium tungstate may be isolated and purified before being passed on to the main process. The next may be described as the principal process, to which the foregoing are preliminary steps.

The processes already mentioned may be grouped in one building, and those described below in adjoining ones, which need only be separated by party walls. The first group of appliances in this building, all placed on the ground level, would be hand-fired reverberatory furnaces, into which the ground ore and soda in suitable proportions are fed and heated to a temperature of about 1,000 deg. C. The material is here subjected to constant rabbling. These furnaces need not, if skilfully designed, occupy an undue extent of floor space. They are fed on one side with the ore and are stoked from the opposite side. Flues below the floor connect the furnaces with a centrally placed chimney, which may be carried to a height of 150 ft., with an internal diameter of 9 ft.

It is all-important that all ore mixtures be carefully selected, so as to yield a uniform furnace product. When the contents of the furnace have been raised to the desired temperature, the molten mass is drawn into slag pots. These are then wheeled to a convenient point where they can be handled by an overhead electric traveling crane. The pots are allowed to cool, and are then raised and tipped, so that a solid lump falls out, which must be reduced to 1-in. cubes. The lumps are readily broken to a suitable size by hammers, and the material is then fed into a jaw crusher, from which the 1-in. cubes are obtained. These small cubes are later ground to a fine powder so as to fit them readily to be acted upon by chemicals. These grinding processes constitute the third operation.

The next process is the fourth, for which a separate room also should be provided. The finely ground melt is placed into a number of steam-heated circular vats in which the soluble tungstate of soda is extracted. Mixers are provided in the vats, and the solution of sodium tungstate, and, in suspension, finely divided oxides of

iron, manganese, lime and silica, is then forced through filter presses. The resulting clarified solution contains essentially sodium tungstate, the purity of which depends upon the absence of sulphur and other elements which form soluble compounds with soda. Tin oxide, which occurs in many of the ores, especially those coming from the East, under correct working conditions does not become soluble, and remains in the filter cake. The steam required for this department or room is devoted to the fifth process, carried on in a series of special vats placed on a raised platform. The tungstate of soda is treated with hydrochloric acid, which is elevated by compressed air, and is thus broken up into solid tungstic acid (WO_3), and sodium chloride, which is left in solution. This solution, with the WO_3 in suspension, is conveyed to another series of vats, in which it is washed by decantation to rid it of soda salts.

It is important to remove as much of the water as possible, and, after the final wash, the WO_3 is brought to a creamy consistency by the remaining water being siphoned off. This cream is then conveyed to a number of centrifugal machines, in which the WO_3 collects along the inner face as a thick, deep chrome-yellow paste. It is dug out with wooden spades and has then to be finally dried in a series of bottom-heated stoves. This drying operation is the sixth of the processes necessary to obtain the pure metal from the ore, and also requires its own room. The chemical processes are now complete, as the only remaining operation is that of converting the oxide into the pure metal, a simple metallurgical treatment using heat and a suitable reducing agent, such as carbon, a hydrocarbon, hydrogen, zinc, or aluminum.

Pure Metal Obtained by Smelting With Reducing Agent

This last operation also takes place in a separate shed, and is carried out by means of a number of specially designed furnaces. The yellow paste is conveyed into the ends of the furnace, within which it is raised to a high temperature in contact with the reducing agent. The output of these furnaces is a black material, which is conveyed into the eighth, the last of the series of buildings, in which it is ground to a powder, washed, dried and poured into tin cases of any convenient size or weight. These are soldered and packed in wooden boxes or metal containers.

The first six of these processes are necessary because the tungsten oxide, WO_3, is found in an impure state; whenever a deposit on a commercial scale of the oxide should be discovered, they will be unnecessary, as the oxide could be at once converted into the metal. Small deposits of the yellow oxide have been found, but not in sufficient quantity. A well-arranged tungsten works of moderate size should be able to turn out from three to five tons of the pure metal every day. Extreme purity is the essential point to be sought, as impurities in the tungsten affect the quality of the steel.

As regards ferrotungsten, it is obtained from the ore by the removal of the oxygen from the combined oxides, thus leaving an alloy of tungsten and iron. Ferrotungsten has been produced extensively in several European countries. The practice differs from that in an ordinary tungsten works, like the one described above, in that the ore is melted direct, and the impurities are to a certain extent retained. It follows that only high-grade ores can be used, and even then impurities cannot be eliminated altogether.

Drying Native-Sulphur Samples

By Albert G. Wolf

Written exclusively for *Engineering and Mining Journal*

IN PROSPECTING for sulphur in the Gulf coast region, the rotary method of oil-well drilling is used. This method, with certain changes, has been found best adapted to penetrate the unconsolidated sediments above the sulphur-bearing stratum and obtain the cuttings of the stratum for inspection and assay. The sulphur-bearing stratum occurs at different depths in the various domes, and consist chiefly of calcite and gypsum, more or less vugular, and containing, scattered through the mass, a varying percentage of native sulphur.

The cuttings as brought to the surface range in size from one-half inch or more in diameter down to the finest slime, the larger particles being much in the minority by weight. The cuttings are caught on screens and in settling boxes, usually three or four sizes being made. These samples range in weight from one or two pounds up to fifteen or twenty pounds, depending upon the depth of hole made for one set of samples, and also upon the nature of the hole walls, some parts of a well crumbling more than others. The cuttings, being voluminous, must be dried slowly and carefully, to avoid burning off any of the sulphur. The slime samples are especially large and slushy before drying. If the drilling is progressing satisfactorily, much room is required. For these reasons the drying is best done out of doors, especially in this hot climate.

A satisfactory drying arrangement consists of a pit 1 ft. deep, 18 in. wide and as long as necessary, 40 ft. usually being sufficient for one well. On each side of this hole are placed lengths of old 6-in. casing. These are held in place by iron rods driven into the ground. The samples to be dried are placed in galvanized tubs, No. 2 size being most convenient, and these, in turn, are placed in large water pans. These pans are placed over the trench, resting upon the casing. They are circular in shape and are 30 in. in diameter, 8 in. high, and are bound around the top with ¼-in. round iron. This is bent into a loop in one place so that a hook can be inserted when removing from the fire.

In each pan is placed a triangle made of 1-in. pipe, 12 in. on a side, to prevent the tub from resting on the bottom of the pan, and the sample thereby reaching a temperature higher than that of boiling water. Each 20-ft. length of pit will hold six or seven samples. As it takes sludge samples two days to dry, the necessity for placing outdoors is apparent. A short rod with hook bent in one end is convenient for removing the samples from the fire, and a long-handled chisel is used for stirring the sample to assist in its drying.

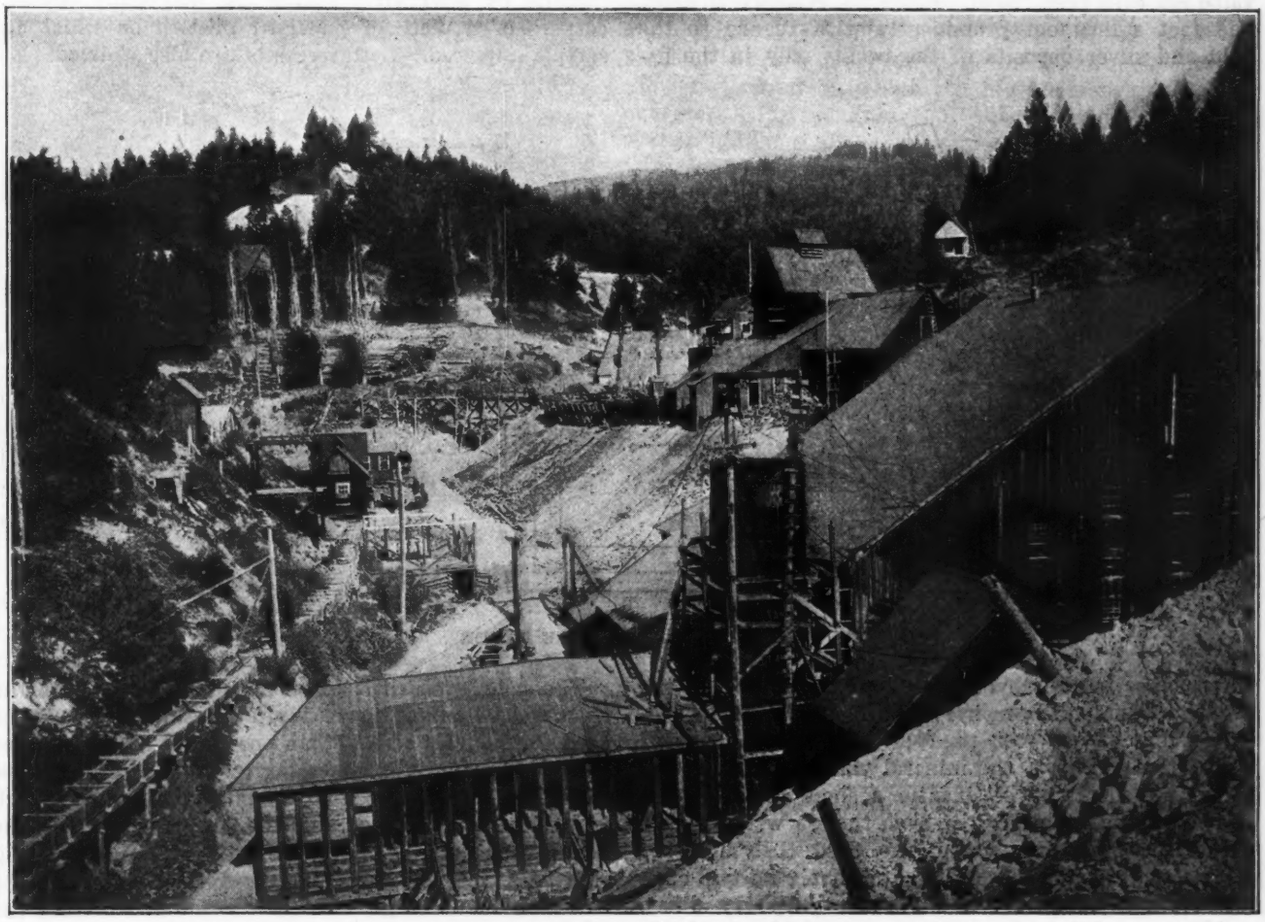
The fuel used is a combination of wood and fuel oil or crude oil. Any sort of wood will do, but cord wood is the best after a fire is once started, as it holds the heat longer. Oil is necessary to assist in starting the wood, and to bring the water in the pans rapidly up to the boiling point and keep it there. There seems to be little choice in the proportions of wood and oil that may be used to advantage, with wood at $8 to $9 a cord and oil at $1.55 a barrel. For convenience in carrying on the work, it is well to run a water line from the boiler feed-water pump to a barrel near the pit, and a second line, for oil, from the fuel tank.

The Boise Basin District in Idaho

Camp Which Was the Scene of Former Placer Mining Activity Shows Signs of Revival—Dependable Orebodies Found in Fissured Zones in Rhyolite Porphyry Dikes—Results Of Recent Explorations Justify Further Extension of the Work

BY S. M. BALLARD
Mining Engineer, Placerville, Idaho
Written exclusively for *Engineering and Mining Journal*

DURING the last three summers, I have had an opportunity to make a study of the geology of Boise Basin, Boise County, Idaho, with a view of ascertaining its relation to the mining industry. The following, which is a general survey of conditions found there, will probably be of interest to those engaged in mining, because similar conditions and possibilities may exist elsewhere.



GOLD HILL MINE AND MILL, QUARTZBURG, IDAHO

This Boise Basin region has been covered in a very general way by U. S. Geological Survey reports, but I believe that more detailed information will be necessary to afford a proper comprehension of the field and its economic importance, as the Survey reports touch only slightly upon what is believed to be the important feature of the ore deposits included in the belt.

Boise Basin is about twenty-five miles north of Boise, Idaho, and was the scene of much activity in past years when placer mining in the West was at its height. Practically every gulch that could be reached by water was worked. In the higher regions, snow-water was conserved, and the gulch bottoms were cradled. But the placer days are gone, and the many thousands of men who swarmed over these hills have left their mark in the countless ditches and placered gulches that are to be seen so extensively throughout the basin. Often, placer workings are to be found near the tops of the ridges. These higher deposits were not bench gravels, but the result of the erosion of outcrops of the immediate vicinity.

Roughly, the mineral belt, which is not confined to the basin alone, is about forty miles long by five miles wide, extending from Pearl, Idaho, northeasterly through Quartzburg and Placerville, to what is known as Summit Flat, about fifteen miles northeast of Idaho City. It is not definitely known that the belt terminates at this place. Granite is the country rock of the region, no sedimentary rocks having been seen at any point in the area under consideration. In the granite

are countless intrusions of diorite and rhyolite porphyry dikes which extend in a general way along a course parallel to the belt as outlined. It is to the rhyolite porphyry dikes that special attention is called.

The rhyolite porphyry, or quartz porphyry, of the region is found in countless parallel dikes generally 30 to 40 ft. wide and often only 100 to 200 ft. apart, extending generally northeast and southwest, and these are traceable on the surface for many miles. The rhyolite cuts through the diorite in nearly every case, and is, in turn, often cut by small diabase dikes that seemingly have no uniform direction or mode of occurrence, but may be found extending, in certain areas, in many different directions.

The only rock of any economic value, as regards local mining, is this rhyolite porphyry. It is not believed, from evidence found in old workings, that this fact was realized by early-day quartz miners. Had it been, much useless work would not have been done by them in the granite and diorite, where little or nothing of value has ever been found. From the evidence at hand, one fact stands out prominently with regard to the gold and silver deposits of the basin: only in the fissured zones in the rhyolite porphyry dikes, or on the contacts where this porphyry is one wall, have dependable bodies of ore been found; where the fissures cut across the porphyry, the mineral values will be found to extend out into the granite a short distance, but seldom out into the diorites, even though well fissured.

For the last three years, the Gold Hill mine, at Quartzburg, has been working exclusively on two such intersections of fissure and rhyolite porphyry dikes, and has proved the values to be as dependable at a depth of 500 ft. as at any point above. This mine held first place for gold production in Idaho during 1919.

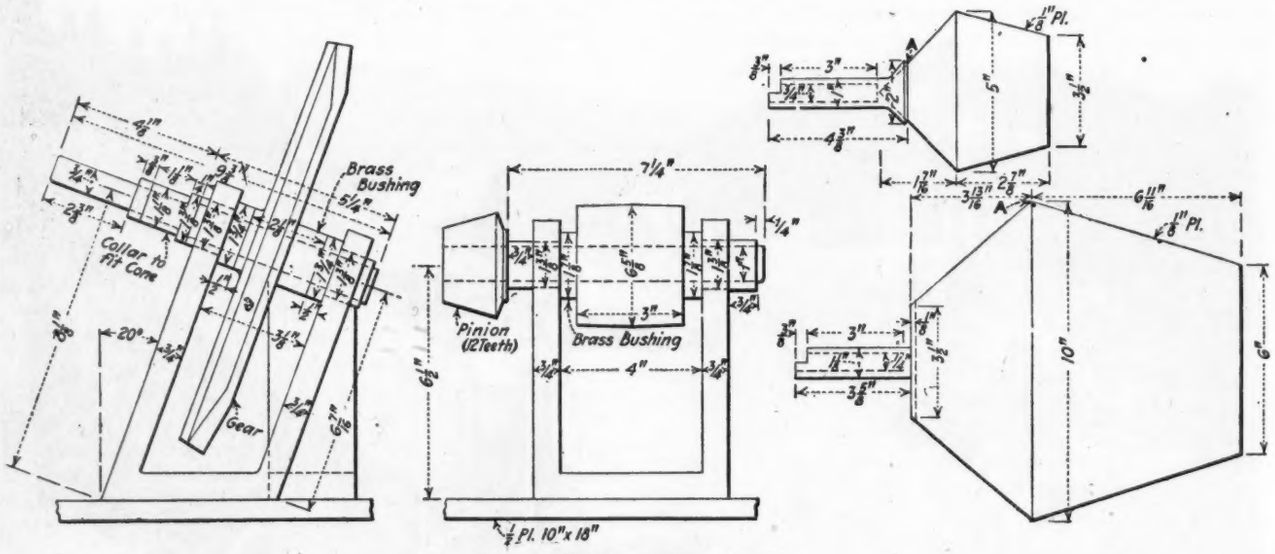
Examination of the different deposits leads to the conclusion that those along the northern confines of the belt are primary, the gold and silver mineralization being associated with stibnite, sphalerite, and in a few places with galena, all generally in a quartz gangue.

Gold values along a considerable portion of the southern margin of the belt are found associated with pyrolusite. A rather contradictory condition exists in this area, where manganese is found, in that there are many extensive placer workings which are known to have paid well. No positive evidence of rapid erosion is to be observed to account for this fact.

So far, a realization of the true situation as to the ore occurrence has begun to take hold only among mine owners along the belt. On the strength of the idea of the ore deposition as outlined, two mines have recently begun development work after lying dormant for several years. Two more did considerable preliminary work last fall, with a view to starting this spring as soon as the season permits. It is with much interest in the outcome that the results of the work of this year are awaited locally, for, in the words of the old timer, "the ground h'aint scratched yet."

A New Mechanical Sample Mixer

The sample mixer shown in the figure has been devised by P. P. Daume, master machinist of the Rogers mine, Munro Iron Mining Co., Iron River, Mich. It is designed to eliminate the tedious hand mixing of samples by alternately lifting the diagonally opposite corners of a piece of paper or oilcloth on which the sample is placed. Better results are also claimed.



MECHANICAL SAMPLE MIXER

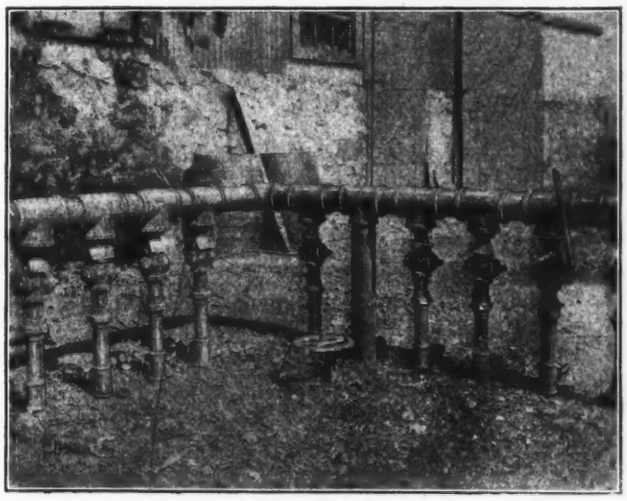
The sample which is to be mixed is poured into the open end of one of the cones. The small cone can be used for samples of less than one pound and the larger cone for amounts up to twenty or twenty-five pounds. The cone is then slipped on the end of the shaft, which is inclined upward at an angle of 20 deg., the end of the hollow cone shaft engaging the cut collar of the driving shaft. A rate of about forty revolutions per minute has been found to give the best results in mixing the sample.

The Radium Watch Industry, which has grown in a few years to such large proportions, began with the production of one watch in 1903 by Dr. George F. Kunz, according to the New York *Tribune*. In 1913 about 8,500 radium watches and clocks were sold in the United States, and by 1915 there was more than a fivefold increase in this number. From these small beginnings the uses of radio-luminous compound has grown into an industry with an output which in 1919 approximated 2,200,000 American high-grade and cheap watches and clocks and upward of 560,000 imported timepieces.

Fire Protection of Surface Plants

Careful Planning Necessary—Provision for Small and Large Fires Requires Several Kinds of Apparatus —Advantages of Multiple Protection

PRACTICALLY every mine manager must consider the question of adequate fire protection for the surface plant under his charge. Few systems are available, and most of them depend on a supply of water under pressure. The methods in common use are: fixed monitors so arranged as to permit a heavy stream of water to be directed as desired; supply pipes and hose reels placed at central points both within and without the plant, the length of hose attached to the pipe being sufficient to serve the area not covered by other hose lines; supply pipes at important places and a hose reel which can be pulled by hand to any place where a fire starts; hand fire extinguishers of several types placed at danger points; chemical fire engines, and the sprinkler system.



FIRE MANIFOLD FOR SPRINKLER SYSTEM AT EMPIRE MINE, GRASS VALLEY, CAL.

Monitors are useful only where there is a large water supply under a high head. This water supply can be secured by providing a special tank or reservoir of sufficient size, so situated as to give the necessary head. The importance and value of the plant may well warrant such an installation. The supply pipe and stationery hose reels have the objection that fire hose rapidly deteriorates and is often in bad condition when it is most needed. A system of regular inspection will obviate this objection, although the expense of replacing unreliable hose will be considerable. This method may not be suitable for every part of a plant, but it is valuable at shaft mouths, and should at least be installed there.

The portable hose reel has the advantage of cutting down both the amount and cost of the hose required by the previously mentioned system, and a more durable hose consequently can be provided. The objection is the time consumed in bringing the hose reel up to the place where it is required and the confusion of coupling and making up the hose line. The hand fire extinguishers are excellent as auxiliaries and for incipient fires, but are useless for a large fire. They should be liberally distributed in change houses, shaft mouths, woodsheds, and wherever a large amount of combustible material is stored. The chemical fire engine of the hand type is also an important auxiliary, but cannot be seriously considered for a large fire.

The automatic fire sprinkler system has the important advantage of being ready for any fire which may break out within the zone served by the system, and its operation does not depend upon the discovery of the fire by an individual. An interesting modification of this method is in use at the surface plant of the Empire mine at Grass Valley, Cal. At this mine each part of the plant is provided with a sprinkler system, which, however, is not automatic. Each sprinkler head has the automatic release removed, and the pipes are kept empty. The plant is divided into sections, the sprinklers in each section being served by an independent pipe line which is run to several central points where connection may be made by manifolds, as shown in the illustration, to a high-pressure water line. The water may thus be turned into the section which is on fire, at any one of several convenient places. The manifolds are painted red and are conspicuous by standing above the ground in a convenient and readily accessible place. Each branch pipe is labeled. In the foreground of the picture is shown the hand wheel by which the high-pressure valve is operated. The advantage of this modified sprinkler system is that scale, which almost invariably accumulates in iron water pipes under pressure and which interferes with the proper operation of the automatic sprinkler, does not form, so each sprinkler head can function properly when necessary.

The selection of a fire-protection system requires comprehensive planning, which is justified even in small plants. In the first place, the plant should be separated into as many accessible units as possible. If convenient, distances between the separate parts should be made sufficiently large to prevent fires from spreading. One or more of the inner buildings can sometimes be built with brick end walls to act as fire stops.

In selecting fire-fighting apparatus, chemical engines and hand extinguishers should be provided for small incipient fires, but for larger ones a plentiful supply of water is necessary. At the Empire mine, referred to before, monitors are placed in the spaces between the buildings; hose reels are put at several points; both extinguishers and a chemical engine are provided as well; but most reliance is placed on the sprinkler system in case of serious trouble.

White Paper the Best Test Plate

In the case of those volumetric determinations in which it is necesasry to remove drops of the solution for testing, a sheet of non-absorbent white paper will be found far preferable to the porcelain test plate commonly used. Apart from the great advantage of the paper in point of cost and unbreakability, drops on a sheet of paper assume a deep hemispherical shape, and, in consequence of the greater depth of liquid viewed, the end point can be determined with greater accuracy. Unless a porcelain plate is absolutely dry, drops are likely to "run," and in any event never tend to assume the deep hemispherical form they do on paper.

[White paraffin, melted, poured in a soup or dinner plate as a mold, and allowed to harden, also makes a cheap and excellent test plate.—EDITOR.]

Modern Drill Runner and the Blueprint Round

Intimate Insights Into the Real Mud-Digger's Thoughts—Systematic Operation With Multitudinous Accessories Is Perhaps Not the Last Word—Theory Requires Admixture of Horse Sense.

BY HARRY E. SCOTT

Written exclusively for *Engineering and Mining Journal*

THOSE were happy days when the drill runner after a job went to the collar shaft and "Bumped the Boss." He might "get on," or he might not, but if he was lucky and got a job, all the equipment he needed was a candlestick, and not necessarily this; an old piece of wire would do the work until pay day. Things have changed since those good old days for the "mud digger." Now, when a man desires employment, he goes through the routine of the camp in which he happens to land. Different mining companies have different systems for the employment of men. All details have been attended to, and he is told to report in the morning, ready to go to work.

The new recruit appears on the job the next morning with a nicely polished carbide lamp in one hand and a suitcase in the other. In the latter will be found his tools, among which will be paper, pencils, charts, reference tables, compass, square, plumbob and string; also, a tin wash dish, soap, and towel will come in handy, as a drill runner occasionally gets his hands soiled, and his hands must be clean to handle the apparatus required to drill the up-to-date round.

All these tools are nice to look at, but to those of us who have only recently learned to write our name on the payroll, instead of making a cross, it would be impossible to follow directions, for if we saw X over Y we would not know which were the cut holes, as these letters both intersect.

REFERENCE TABLES USED FOR SHOVELING DIRECTIONS

In these modern times, a drill runner is allowed to pick down and muck back, but before doing this he should consult the reference table headed "Shoveling." This will give him the proper degree of curvature for the spine, number of pounds per shovel, and number of shovels per minute to obtain the desired result. By the time this is done the "setting up" expert arrives. After due consideration and deliberation the place is spotted for the bar or column, one pick handle plus a cigarette from the face. The next one to arrive is the "hardness expert," with a roll of papers under his arm. He gives the dip, angle, and spur dope; also proper pitch for cut holes. Then set the drill, with the assistance of the compass, square, and degree plate on the saddle. Now you are ready to turn on the air.

After the cuts are drilled consult your reference table. First, however, wash your hands, as it takes much time to make out these tables, and they should be kept as clean as possible. Take all the time you desire to study the forms. A drill runner always has lots of time to spare; if not, cut a few inches off of the bottom of each hole.

Sometime during the shift the powder expert appears, taps the rock a few times with his little pick and tells the drill man how much powder it will take to break the round, and what per cent; also which way to point the fuse.

The air drill, not being a very beautiful piece of machinery to look at, the attachment of reference tables and instructions for their use, made on shiny copper plate, will help the appearance of the drill, providing the company will furnish a can of gasoline and a nice flannel rag to keep them clean, so that the operator will be able to make out a few of the characters, should he be endowed with enough gray matter. But, with a very large percentage of the men in this occupation unable to speak the English language, much less read it, plates would have to be made interchangeable and in many languages. Some drills would need a different plate on night shift than on day shift. The time lost in doing this need not show on the daily report as a delay in drilling.

POSSIBILITIES OF THE UNDERGROUND MOVIE

From all indications, it is to be expected that moving-picture machines will soon be installed underground. One of these, set up behind the drill column, projecting pictures on the face of the drift, will show the drill man each move he should make while in the process of drilling a round. It will also picture the holes as they should be drilled, showing, while not otherwise engaged, pictures of explosions caused by drilling in or near missed holes, and depicting other unsafe methods.

It certainly would be a pleasure to stand on your head to look at the scale and plumbob while holding a jackhammer, carefully starting a hole. Another nice job would be lying on your back in the mud and slush in the bottom of the drift, looking up at the scale on the saddle when the drill is turned under the arm.

A *miner*—(not the kind they are making these days—thirty days underground and they are world beaters—but a real miner—one who has worked from five to twenty years at the game)—does not guess at the holes he puts in, any more than he does at the timbers for his own protection. Even should he guess at the holes, he undoubtedly would have as good luck, being familiar with breaking ground, as the blueprint expert, on his first job, trying to pull off some of the things he has learned.

No blueprint rounds were used in the Newhouse Tunnel, in Colorado; the Taft Tunnel, on the Milwaukee railroad, in Montana; the Roosevelt Tunnel, at Cripple Creek, Col., nor in many more works which could be mentioned, to show how to break the ground. A bunch of drill runners on the crank did the work, and they went some, the muckers never getting the kink out of their backs trying to keep the muck out.

It is to be admitted that the efficiency of the air drill, as handled by many, is way below par, but, to raise this, the drill runners will have to be educated in a different way than by blueprints, for a man who can read a blueprint and use the information effectively will not remain long underground as a miner.

4001
Bumping the Boss for a Job
With a nicely polished carbide lamp in one hand and a suitcase in the other
Lying on your back in mud and slush in the bottom of the drift.
The Reference Book on Shovelling and the Hardness Expert.
The Powder Expert appears, taps the rock a few times with his little pick.

By The Way

Flotation Process Outclassed

The following letter has been received by an engineering company:

Dear Sirs:—

For some time your Co.'s add has appeared in the *Mining Journal.* Surely after all the lawing that has taken place in Canada and the U. S. over this Rotten German oil flotation business, this thing would die out and others dealing in this oil would have something up to date such as the Universal Dry Ore Separation Air Gravity and Oscillation Process—a perfect machine, perfect system—just a Breaker, a sett of corrigated Rolls, a sett of Smooth Rolls, that is all. Automatic. Three men putting through 100 tons in 8 hours, costing about 15 cents per ton from the miner to the smelter.

At the End of Each shift—there is the Bullion. just a flour mill system. I am the sole owner for Canada of two Systems. two distinct machines of any capacity.

And one of the machines will seperate Grains, or Cereals as perfectly as any minerals, and a perfect seperation.

I have seen this oil flotation business in all its fasiss Rotten business know the Engineer know Beer and Snodenhimer. Fakers The Government ought to prosecute any one practicting this abominbal system. and 10 Royalty.

My system puts it on the bum also Wiflies. and Vaneers and that Deister another faker. jigs and settlers trummels and mills all to the scrap heap. The Hardy Marcy bunch is the biggest faker of them all, with or without end screens.

Time and life is to short to waste with oil flotation or any other flotation get away from it.

I have Four machines three Patents cover the four machines.

One is a Placer dredge it gives the contents of the materal as it works. Gas power or any kind of power.

One is working on the North scheckenau River on the sand and gravel bars with good results.

I am very truly,

P. S. My machine will separate any mineral Gold. Silver. Copper. Lead Zinc. Molybdenite Graphite—Cornetite Roscotite—Asbestos Barite Chromite—iron sands all iron oxides iron screws nails from scrap—and in crucible & pencil works.

An Early Arrastre

In an Arizona chronicle of happenings forty years ago is found the tale of a mill then operated on the Jo Green and Excursion mines of the Tonto Basin section. A half-dozen miners, remote from hope of proper machinery, had built an arrastre 22 feet in diameter, with a circular trough seven feet wide in which ponderous stones were dragged by the power of four yokes of half-wild range cattle. The scene that ensued when the bulls were yoked up and the ponderous machine began to move to the music of an incessant fusillade of whip cracking and profanity was said, by a local historian, to have "beggered description." Three tons of gold ore a day was handled.

The Nasal Process

An inquisitive and talkative book agent, sojourning in a mining camp, ferreted out prospects in every sense and appointed himself as a special investigator of everyone else's business. Picking up a chunk of apparently barren quartz from a pile destined to be used as a flux for carbonate ores, he looked it over casually, and then examined it with a reading glass such as is carried by every well-appointed book agent. Failing to observe any indication of value, he glanced around and asked the nearest victim, "How in thunder did they get the idea that that stuff is worth shipping?" The efficient assayer smiled a welcome and politely answered, "That, sir? Why, we smelt it." The bore nodded comprehendingly and said, "Oh, I see, I see." Soon after he was observed furtively sniffing at one rock after another that he picked off the dump. After several negative shakes of the head he made a gesture of despair and grumbled, "Some of these smart guys around this camp call me nosey, but I guess my nose is not the right kind of nose for the mining business."

Political Confidences

"With all this 'ere talk goin' h'on baout polytics an' so forth," says Cap'n Dick, "a man 'hardly naws w'ot's w'ot, an' it do seem as if there should be some way o' findin' h'out jus' 'ow well fitted a man is for to 'old a job afor' 'e's put on tha slate to be voted for. W'y, dam-me, it h'appears that we naws but little o' a chap till 'e's put h'up for sumthin', an' then h'after tha gossips 'as 'ad their say 'e 'ardly dares raise 'is 'ead. No matter 'ow straight 'e be, there's boun' to be some scandal or sumthin' drummed h'up by some o' these 'ere 'ooken snivey rascals. The h'other day, Tom Tregillis wuz h'approached by one o' these 'ere fellows lookin' for votes. 'Mr. Tregillis,' sez 'e, 'will 'e vote for Smith?' 'Vote for him?' sez Tom, 'W'ot's 'e runnin' for?' 'Two year term, trustee,' sez tha chap. 'Trust 'e,' sez Tom, 'Dam-me, no—wouldn't trust 'e no place. Would'nt trust 'e one term, let alone two. Gos' 'long naow, talk to someone 'oo don't naw tha bloody beggar well as I do.' All this 'ere aside though, m' son, strikes me this 'ere chap 'Oover should be good timber for tha nex' term at tha White 'Ouse. An', dam-me, 'e's a minin' man, too, they tell me. Wo't think?"

Does the Crow Fly Straight?

Down in Arizona they have gone back to first principles again and are selling stock by methods supposed to have been abandoned long ago. In an advertisement that has appeared in New York and Boston papers offering stock in what appears to be a wonderful copper property, it is told that the mine lies "between the New Cornelia and United Verde mines." As the crow might fly, if he flew straight, the distance between the mines named is just about 120 miles. The New Cornelia is a relatively shallow deposit of leaching and concentrating ores. The United Verde is one of the deepest mines of the Southwest, of straight smelting sulphides. About 1,000 mines and a thousand mountain peaks lie between them. It is possible that the two mines have geologic connection, but it has been generally overlooked, if true.

The Largest Circulation

A famous physician once said that a great trouble with the young men of his day was that they were neglecting to develop their powers of observation. Here and there we notice a similar defect today, and in engineering circles at that. An error has recently appeared in *Mining and Metallurgy*, the new publication of the A. I. M. E., in which the advertising rooter proclaims that "no mining paper now has as many as 9,000 paid subscribers." More accuracy is expected from the Institute, even from its advertising man. He is certainly a wizard at figuring out "paid subscriptions" for *Mining and Metallurgy*, in the course of which he counts in the whole membership of the Institute. However, he is behind the times as to *Engineering and Mining Journal.*

CONSULTATION

Dry Crushing and Direct Cyanidation

"Will you please advise me where I can secure the latest data on dry crushing and cyaniding direct?

"I have a large tonnage proposition, consisting of about 500,000 tons of old mine dumps, which I believe could be successfully treated in this way. The material is free milling but low grade, and contains considerable clay. It will average about $3.50 per ton in gold and silver, 80 to 85 per cent being in gold."

The latest data on this subject can best be secured by going over the files of the *Engineering and Mining Journal* for the period between 1905 to 1912, or by consulting such books as H. A. Megraw's "Details of Cyanide Practice," Richard's "Ore Dressing," on the subject of dry crushing, or other similar books. We do not know of any recent examples of dry crushing and cyaniding plants, although at one time there were a few such plants in operation.

By your question we presume that you intend to dry crush the ore and then treat it by leaching with cyanide solutions. Such a plant and process would be relatively simple if a sufficient recovery could be made with ore reduced to 20- or 30-mesh size. The crushing would be effected by rock breakers and rolls. As you say that the ore contains considerable clay, you would undoubtedly have trouble in both crushing and leaching. To avoid this, crushing could be done wet by stamps or ball mills. The clay in the form of slimes could be separated by classifiers from the sand, and both treated separately, the sands by leaching, the slime by agitation and filteration. There were many sand-slime cyanide plants in the period first mentioned.

A slime plant would also be applicable under circumstances where the gold occurred associated with the slime. Two excellent examples of cyanide plants for treatment of gold are given in Vol. 60, p. 78, 98, *Trans.* A. I. M. E., "Elko Prince Mine and Mill" and "Fine-Grinding Plant of Barnes King Development Co."

Copies of these papers can be obtained by writing to the Secretary of the American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York. A nominal sum is charged.

In your description of the ore you mention that it is free-milling but low grade. This suggests that one of the simplest methods would be stamp or ball mill crushing and plate amalgamation. A mill test of a large sample, 50 or 100 tons, would quickly give the facts to determine the feasibility of this method.

In a problem of the kind presented, the crucial points are the average value, the recovery by some simple method, and the cost of treatment. A quantity of the magnitude you mention, with the value you name, would warrant employment of a competent metallurgist. Often a reasonably good proposition fails because the principals attempt to solve highly technical and mechanical problems out of all proportion to their ability. It is the part of wisdom and common sense to get the best technical advice before spending money. Accurate estimates of cost, a clean-cut plan, well-thought-out designs and a plant of good mechanical arrangement stand between success and failure.

What Prices Are Paid for Iron Ores?

"I believe that I can make discoveries of iron ore in my locality, and would be interested in ascertaining prices paid for iron ores and the conditions under which they are marketed."

The opportunities of marketing iron ores depend on present and future demands of the furnaces and the price at which the ore is offered. From present reports, it is indicated that stocks are low at the furnace yards, and there will be considerable accumulation of large stocks during the shipping season in order to avoid the difficulty in getting shipments should a coal shortage interfere with the movement. This condition applies particularly to the situation in districts which draw their supply of iron ore from the Lake Superior region. There are, of course, markets other than these, and if you could give us some idea as to the location of the deposits you mention, we could write more definitely on local conditions and markets, or at least explain where such data may be obtained.

The unit value of standard Lake Superior iron ores is determined by adding an arbitrary amount, representing rail freight from the base point to the furnaces, to the market price of a ton of the base ore, and dividing the total by 55 in the case of a bessemer ore, or 51½ in the case of a non-bessemer ore. The selling price of any ore is determined by multiplying the natural iron by the unit value and deducting penalties or adding premiums for phosphorus content. Present prices on Lake Superior ores are as follows:

Old Range bessemer	$7.45
Old Range non-bessemer	6.70
Mesabi bessemer	7.20
Mesabi non-bessemer	6.55

These figures apply to only one locality, the Lake Superior district, and the quotation in other parts of the country will differ with the furnace demands and requirements.

Leading Mining Publications in England

"What are some of the important mining publications of England?"

Corresponding to the *Transactions* of the American Institute of Mining and Metallurgical Engineers are the *Bulletin* and *Proceedings* of the Institution of Mining and Metallurgy, No. 1, Finsbury Circus, London, E. C. 2. A similar publication is the *Transactions* of the Institution of Mining Engineers, 39 Victoria St., S. W. 1, London. A few of the "mining papers" follow:

Birmingham Engineering and Mining Journal, 39 New St., Birmingham.

Colliery Guardian, 30-31 Furnival St., Holborn, E. C. London.

Mining Journal, 15 George St., Mansion House, E. C.

Mining World and Engineering Record, 234-236 Gresham House, London, E. C. 2.

Mining Magazine, 724 Salisbury House, London Wall, E. C. 2.

THE PETROLEUM INDUSTRY

Gas an Important Factor in Oil Accumulation

Interesting Experiments by the Department of Geology of the University of Minnesota Demonstrate Effect of Gas Upon the Segregation of Oil From Oil Sands—Difficulty of Duplicating Field Conditions in the Laboratory

BY GEORGE A. THIEL

Written exclusively for *Engineering and Mining Journal*

THE relations of accumulations of petroleum to geologic structure were first discussed by Andrews, Hunt, and Winchell. These men formulated the "anticlinal theory," and described three types of geologic formations that are essential for an oil accumulation: (1) A carbonaceous strata from which the oil is supplied; (2) a stratum of porous sandstone or fractured limestone to serve as a reservoir; and (3) an upper argillaceous strata forming an impervious cap above the oil-bearing strata.

The anticlinal theory did not meet with the general approval of geologists, on account of the various contradictions discovered in the Pennsylvania oil fields, which were then being exploited. It was not until 1890

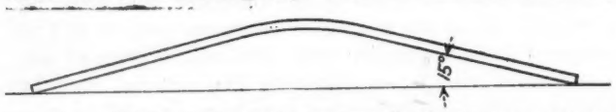


FIG. 1. GLASS TUBE FILLED WITH OIL-SAND AND SEA WATER, WITHOUT GAS. EXHIBITS NO EXTENSIVE ACCUMULATION OF OIL

FIG. 2. GLASS TUBE SHOWING GROUND DOLOMITIC LIMESTONE INTRODUCED AT *A* AND *A'*. THE SYSTEM WAS FILLED WITH OIL-SOAKED SAND AND ACIDIFIED SEA WATER

FIG. 3. GLASS TUBE SHOWING THE RESULTS OF FORTY-EIGHT HOURS' ACTION ON TUBE AS SHOWN IN FIG. 2. *A* AND *A'*, DOLOMITE; *B* AND *B'* SEA WATER IN SAND; *C* AND *C'* SEGREGATION OF OIL IN THE SAND; *D*, ACCUMULATION OF GAS IN SAND

that I. C. White placed the theory on a working basis. He was convinced that the theory was corroborated by facts as observed in the Pennsylvania gas fields, and he later worked out many of the details and applied them in a practical way in locating new and undeveloped fields.

Other theories or modifications have been advanced, among them the hydraulic or hydromotive theory as advocated by Munn; the diastrophic theory, by Daly; and the theory of capillary concentration as put forth by Washburne. Each theory, though different in the detail of its application to oil accumulation, is dependent to a great extent upon the difference in specific gravity between salt water and crude oil. It has been shown experimentally that the force of gravity alone is not sufficient to overcome the viscosity and adhesion of the oil. Other factors must therefore be taken into consideration in attempting to elucidate the problem.

The following experiment shows the influence of gas under pressure in oil accumulation:

A piece of glass tubing four feet long and with a bore an inch in diameter was bent in a wide flame to avoid a sharp angle at the point of heating. The tube was bent about fifteen degrees from the horizontal. Crushed quartzite that was sifted through a twenty-mesh screen was partially saturated with crude oil to which one-third of its volume of kerosene had been added. The quartzite and oil were allowed to remain in the mixing pan for a few minutes, in order that the oil in the highly saturated portions might drain to the bottom of the pan. Only quartzite sand with the amount of oil it retained by means of adhesion and capillarity was used in the experiment.

One end of the glass tube was then temporarily plugged with a rolled paper plug four inches long. The oil-soaked quartzite sand was placed in the tube and saturated, during filling, with sea water that was acidified to one-half of 1 per cent with acetic acid. Four inches at each end of the tube was filled with fine-ground dolomitic limestone (Fig. 2, *A* and *A'*), and tight-fitting rubber corks were inserted. The tube was then placed in the position as shown in the figure, and the ends were blocked to hold the corks in position.

The acidified salt water, upon coming in contact with the dolomitic limestone in the ends of the tube, generated carbon dioxide, which slowly diffused through the entire system and developed considerable gas pressure. In twenty-four hours the oil was segregated in the upper portion of the limbs of the tube. (Fig. 3, *C*.) and a pronounced accumulation of gas was seen at the crest of the structure (Fig. 3, *D*). In forty-eight hours the separation was still more nearly complete, and a sharp line of demarkation separated *B* and *C* of Fig. 3. In the upper part of the limb of the structure, near the accumulation of gas, the oil occupied all of the pore space of the sand throughout the entire diameter of the tube. The line of separation between oil and salt water was horizontal.

To determine whether the presence of the gas was an essential factor in bringing about the segregation of the oil, several tubes were filled with the oil-sand mixture

and water, without the presence of the generating gas. These tubes showed only small local accumulations of oil in the larger pore spaces throughout the entire length of the tube, with no marked segregation at the top of the structure.

Various theories have been advanced concerning the methods by means of which gas is capable of conveying petroleum. W. H. Johnson suggests that a bubble of gas rising through water, and coming in contact with a globule of oil, unites with it, and the oil forms a continuous shell or film about the bubble. He believes that oil is carried to the top of anticlines by this process. In this experiment, however, the oil was not so carried; the volume of oil moved exceeded the volume of the gas under the prevailing pressure.

Lewis, in discussing methods for oil recovery, suggests that gas or compressed air works the oil into a froth and that bubbles are continually forming and breaking in the pore spaces of the sand, and in this manner carry the oil in the direction of the movement of the gas. He believes that three physical processes are involved: (1) direct pressure; (2) the gas goes into solution under great pressure, and, upon being released, carries the oil with it; (3) the gas carries oil as vapor.

To attempt a determination of the method by means of which the carbon dioxide brought about the segregation of the oil as seen in the tube in Fig. 3, a similar experiment was set up with the tube inverted, thus forming a synclinal structure. The first evidences of accumulation were seen at the upper surface of the tube throughout its entire length. At the end of thirty-six hours, however, the oil had moved in both directions from the trough of the syncline, forming a concentration in the upper part of the limbs, immediately below the contact between dolomite and quartzite. Such behavior indicates that the migration of the oil is not dependent upon the direct movement of the gas, as the oil moved toward the source of gas supply. This did not occur until after a uniform pressure had been developed throughout the oil-sand and water mixture.

Any oil will absorb a fixed amount of a given gas, but the coefficient of absorption varies directly with the pressure and inversely with the temperature. Under similar conditions petroleum absorbs about ten times as much gas as water. Burrell has shown that certain California oil absorbs 15 per cent of its volume of natural gas from Pennsylvania wells. In applying such observations to the experiments described above, it must be granted that sufficient pressure was developed in the tubes to necessitate a fair degree of absorption. The pressure due to the excess gas present is the chief factor in bringing about the migration and segregation with relation to the differences in specific gravity of salt water, oil, and gas. These relations, as shown in Fig. 3, are identical with conditions as found in the oil fields where the three constituents are present. Numerous attempts have been made to duplicate the conditions in the laboratory, but gravity and capillarity alone have not succeeded in reproducing the relations as observed in the field. The action of gas in the closed system, in my opinion, points the way to the mechanism of the separation.

I desire to acknowledge the credit due to Dr. William H. Emmons, at whose suggestion this work was undertaken and whose advice and criticisms are sincerely appreciated. The experimental work was done in the laboratories of the Department of Geology, University of Minnesota.

Kerosene and Fuel Oil in Relation to Internal-Combustion Engines

OF INTEREST to oil producers are the following statements, taken from an article by N. A. C. Smith in the February number of "Monthly Reports of Investigations by the U. S. Bureau of Mines":

"The quality of gasoline will not change much in the near future. If the engine and the carburetor of today can use the present quality of gasoline in a satisfactory manner, they can continue to do so for some time. Furthermore, it is probable that the idea of providing for the increase in the number of automobiles by using kerosene as fuel cannot be realized to any great extent. Considerable amounts of kerosene, the total production of which in this country is only half as much as the production of gasoline, can be diverted to the automotive industry only if automobile users are prepared to pay more than is paid by regular users of kerosene.

"The use of fuel oil in the internal-combustion engine may be the solution of the problem. Fuel oil constitutes over 50 per cent of the products obtained from the crude oils refined in the United States. Some of this fuel oil is a comparatively light and volatile distillate, but much of it is a heavy, viscous tar. It is used today for raising steam under boilers, for making or enriching gas, for cracking into gasoline, for metallurgical purposes, and for internal-combustion engines of the Diesel type. This last use, considered in a large way, is by far the most efficient. And it is in this use of fuel oil that there is most possibility of solving the question of fuel supply for the automotive trade. If engineers are able to design an automobile or truck engine that will use fuel oil in a satisfactory manner, they will relieve the danger of the impending shortage and make possible the desirable extension of the use of the automobile and truck. An automotive engine using fuel oil can compete against any other large user of fuel oil because this will be the most efficient use to which the oil can be put. Consequently, the supply of motor fuel would be limited only by the total supply of fuel oil.

"One important exception must be made to this statement, and that is, that part of the oil now used as fuel can be made into lubricants. There has not been sufficient demand for lubricants in the past to consume all that might be made from the crude oils of the country, and the knowledge of how to obtain high-grade lubricants from certain kinds of oils has been lacking. This knowledge is rapidly being acquired, and it is probable that our chemists will be able in the future to produce satisfactory lubricants from almost any crude. The demand for these products is certain to increase in the future, for it must be emphasized that lubricants are the most necessary of all the products of crude oil. Gasoline, kerosene, and fuel oil might be dispensed with, but the industrial development of today would be impossible were it not for the enormous quantities of oil used to lubricate every moving part of our machinery, and these lubricants can be obtained in sufficient quantity only from petroleum.

"The preceding statements have been made, taking into primary consideration the crude oil supplied by the oil wells of the United States and Mexico. There are, however, several sources of motor fuel which will probably come into use in the future. The most important of these are the enormous quantities of oil-bearing shale, found in the states of Colorado, Wyoming, and Utah.

NEWS FROM THE OIL FIELDS

February Report of Cities Service Company

The Cities Service Company, according to its statement for February, 1920, reported gross income of $2,111,765, an increase of $374,489 over February, 1919. Net income available for dividends on the preferred stock for February, 1920, was $1,881,270, an increase of $322,188 over the corresponding months for the preceding year. The balance available for reserves, dividends on the common stock and surplus was $1,499,512, an increase of $280,785 over February, 1919. Monthly earnings of the Cities Service Company have been showing a steady increase since July, 1919, February, 1920, having shown $811,056 more gross income than August, 1919, with an increase in earnings available for payment of preferred dividends of $798,534, and the increase in balance available for reserves, dividends on the common stock and surplus in the six months' period was $771,539.

The advance in the price of Mid-Continent crude oil to $3.50 per bbl. was a natural result of the condition in the crude-oil market and of the largely increased costs of production, transportation, and distribution of oil. During 1919, oil-well drilling equipment cost increased between 50 and 75 per cent in price, and, on top of this, drilling contractors advanced their rates materially. Financial reports of companies engaged in practically every branch of the oil business indicate that expenses in 1919 were from 25 to 50 per cent higher than in 1918.

Licensing Geologists Not Looked Upon Favorably

The proposal made at the Dallas meeting of the American Association of Petroleum Geologists, that oil geologists be required to take out a license, does not meet with favor in Washington. The matter of licensing geologists and other classes of technical men has come up frequently in the past, and has been the subject of study on the part of several of the Government's bureaus. The invariable conclusion always has been that, instead of protecting the public from the faker, the effect is most likely to be the contrary. The unscrupulous would be those chiefly concerned in securing a license, and owing to their intent and desire, there are certain to be many cases where they will be able to obtain licenses, thus enabling them to impose upon the public more successfully than otherwise would be the case. Professional geologists have as yet given but little attention to the subject, but it is certain that, along with the mining engineers, they will soon have to do so.

Imperial Oil Company of Canada

Active Campaign in Canadian Northwest Is Planned—Drilling Operations To Begin on Peace River

The Imperial Oil Co. is arranging for an active campaign in the Canadian Northwest, following up the geological work done last year by the staff of field experts headed by Dr. Bosworth, and drilling will be undertaken in a number of places where good prospects were found. As soon as weather conditions permit, drilling operations will be started near Fort Norman, on the Mackenzie River, by a party of five men who have been in camp there through the winter in order to make an early start this spring. A second drilling rig was taken last season to the vicinity of Great Slave Lake, where operations will be begun as soon as possible. The company has two drilling rigs in the foothills in the Barzeau field, situated in the southwestern part of Alberta, and another at Czar, in eastern Alberta. It is intended to have three more rigs in operation, but their locations have not been definitely decided on.

During the last two months good progress has been made by Peace River Petroleum, Ltd., in its preparations to begin drilling operations on Peace River. Two complete oil-drilling equipments and three boilers have been purchased and shipped to Peace River. Machinery will be installed in close proximity to No. 1 Consolidated well. John Hallam, president of the company, states that the report of a discovery of oil at a depth of 1,125 ft. in the Victory well has been confirmed. Oil sands were encountered and the drills show 40 ft. of good oil sands, drilling having been stopped to allow of the sands being tested for quantity of oil.

Pacific Coast Fails To Meet Oil Requirements of Navy

According to Washington dispatches, in response to requests for bids for 4,500,000 bbl., of fuel oil for the Pacific Coast the Navy Department received but one bid, of 602,000 bbl., from the Standard Oil Co. of California. Prices quoted were more than 50 per cent under those submitted in recent bids for Atlantic Coast delivery, averaging $1.95 for port delivery, against $4.20 for the east coast.

With the east and west coast bids together falling about 8,000,000 bbl. short of total requirements, the problem presented to the Navy of securing its fuel oil under contract becomes a serious one. In the meantime naval construction is continuing and large capital ships equipped for oil burning will approach completion soon. A solution of the situation appears difficult.

Encroachment of Salt Water in Mexican Oil Fields Exaggerated

Information in possession of the Government is to the effect that the encroachment of salt water in the Mexican oil fields has been exaggerted and is having an unjustified influence on prices. The rapid increase in the consumption of petroleum products, as well as the various factors in the industry making for uncertainty, has caused practically every consumer to rush into the market in an effort to make contracts. Only for a short time, it is believed, will it be necessary to relieve the market of much of its artificial stimulus, but all of the Government oil specialists are agreed that something must be done by American capital to stimulate the production of petroleum supplies in foreign countries.

Arizona Oil Activities

At the well of the United States Oil & Refining Co., north of Bowie, in southeastern Arizona, there was a hurried removal of machinery a few weeks ago, in anticipation of a gas blowout, but it failed to take place. Sinking was resumed, 100 ft. having been made when the rig proved inadequate and heavier machinery was ordered and is now due on the ground. The scheme is financed by Arizona capitalists.

Three drilling rigs are expected to start soon, under contract, on the property of the Arizona Oil & Gas Co., which has taken up approximately 100,000 acres south of Mohawk, Yuma County. At the head of the company is C. W. Meeken, of Denver, and associated with him are W. J. Lyons, of Los Angeles; N. C. Bauch, of Colorado Springs, and J. K. Stewart, of Denver. The last named is a geologist and is in charge of the field work. The Yuma Oil Co. has been reorganized, having paid off stockholders who desired to quit. The company is planning to sink a well in the lower Gila Valley.

In northern Yuma County, twenty miles east of Parker, the C. A. Botzum Holding Co. is drilling in shale. Most of the oil-well drilling in Arizona for more than a year has been near the vicinity of Holbrook, in the northeastern part of the state. The winter has passed with little result from the relatively small amount of drilling.

Heavy Demand for Regulations Governing Leasing Provisions

Demand for the regulations covering the leasing of oil and gas lands is exceeding all expectations. Inquiry also is being made for the regulations covering coal, phosphate and sodium lands. The latter regulations, however, will not be available for several weeks.

NEW PUBLICATIONS

Mineral Deposits. By Waldemar Lindgren. Second edition, 1919. Cloth, 6 x 9, pp. 957. The McGraw-Hill Book Co., New York.

The first edition of Lindgren's great work on mineral deposits has been revised, enlarged, and reset. In the selection of material for the second edition certain descriptions of relatively unimportant districts have been withdrawn and replaced by descriptions of more important ones. The book is not only the foremost compendium of knowledge on the geology of ore deposits, but the full and philosophic discussions of the genetic relations of the world's principal deposits of the metals render it a most important contribution to science.

Two chapters have been added to the earlier edition. One of these is on the hematite deposits of the Lake Superior region; another is on metallogenic epochs. The conception of the metallogenic epochs first treated by de Launay was developed in North America principally by Lindgren in his earlier papers, but was treated only briefly in the first edition of Mineral Deposits. The second edition devotes a chapter to the subject. It treats metallogenic epochs in general, and those recorded in each of the continents separately. He revises his treatment of the gold deposits of North America,[1] expanding it and bringing it down to date. He closes the chapter on metallogenic epochs and the book with the following reference to cyclic changes:

"As we look back over the wide domain of mineral deposits, we perceive the strong tendency to concentration of common or rare elements, by magnetic differentiation, by solution or by mechanical transportation; we perceive also cycles of transformations, based on the laws of stability of chemical compounds. Even when deeply buried, the deposits may suffer many changes. Near the surface they are constantly subject to transmutations involving both concentration and dispersion. A few stable compounds are formed while the rest are of the elements scattered by mechanical and chemical transportation. Some constituents are carried down into the earth by the underground circulation of water, perhaps to form new deposits in other rocks. Ultimately erosion sweeps away the wreckage of the old deposits into basins of sedimentation where the elements may be reconcentrated, be it by direct precipitation or by the aid of living matter. The sediments may again be lifted and corrugated, again destroyed by erosion, and new eras of concentration begin.

"In one aspect the science of mineral deposits is frankly utilitarian, but from the viewpoint of pure knowledge it records the principles governing the cycles of concentration of the elements. It traces the processes by which the primeval gases and magmas have become differentiated into the manifold complexity of the earth's crust."

In the preface to the second edition Professor Lindgren mentions the progress that has been made in the period since the first edition appeared. This, so far as I know, is the only authoritative statement regarding the progress of the science except the annual reviews of progress by Adolph Knopf, which have appeared for several years in *Engineering and Mining Journal* or in *Economic Geology*. From them one gets a rather gloomy view of the present state of the science. We are told that nothing really first class is being contributed to the literature of the subject. Professor Lindgren's comment is, however, somewhat more optimistic. He says:

"During the last six years students of minerals and mineral deposits have made many important contributions to science. Among these may be counted the investigations bearing on magnetic and contact-metamorphic ore deposits, on problems of oxidation and supergene sulphides, and particularly the application of metallographic methods to ores by which the complexity of metallic replacements has been revealed."

W. H. EMMONS.

[1] Lindgren, W., "The Geologic Features of the Gold Production of North America," A. I. M. E. Trans., Vol. 35, pp. 970 et seq., 1902.

The Mount Pelion Mineral District, by A. McIntosh Reid, Tasmania Department of Mines; pp. 84. Geological Survey Bulletin No. 30, Hobart, Tasmania, 1919.

This is an excellent little report describing interesting ore deposits in Tasmania, and has the additional advantage of promptness, the field work having been done in the early part of 1919. The district covered is in Lincoln County, and the copper ores in it were discovered in 1892; the tungsten ores in 1916. This is in a rugged country with mountains carved from great Mesozoic diabase flows, which cover Silurian rocks and Permo-Carboniferous, coal-bearing strata, which in turn rest unconformably on Algonkian schists. There were some olivine basalt flows in Tertiary time. During the Pleistocene there was a glacial period. The fauna is picturesque to our antipodal eyes—kangaroo and wallaby in large numbers supply meat for prospectors, and the "marsupial wolf, tiger cat, and Tasmanian devil" abound.

The Algonkian rocks were intruded in pre-Silurian time by igneous rocks, mainly porphyritic, but including granite, and dense basic rocks. The Silurian and Permo-Carboniferous strata were later; and in Devonian time great stocks of granite came up, but did not reach the surface. All the ore deposits are connected with and follow this granite intrusion, which is contemporaneous with the tin-bearing granites in other parts of the island.

The direction of folding in the Algonkian rocks is along east-west axes. The various subsequent igneous intrusions have a general north-west trend. The mineral veins have a north-west, north-east, or north-south trend, with dips of between 45 and 77 deg., averaging close to 70 deg. They are divided into three groups—tungsten-tin veins, copper orebodies, and silver-lead deposits, all genetically related to the same granite, the different groups, in the order named, occurring in general in increasing distance from the granite contact, and due to successive deposition from the same solutions. The tungsten-tin veins contain also pyrite, chalcopyrite, arsenopyrite and gold: and as gangue minerals carry quartz, fluorite, topaz, and muscovite (gilbertite). The copper orebodies contain as metallic minerals principally pyrite, pyrrhotite, and hematite, with lesser chalcopyrite, galena, zinc blende, arsenopyrite, and magnetite, associated with actinolite, chlorite, epidote, talc, calcite, dolomite, and quartz, all of metamorphic origin. The silver-lead deposits are both fissure fillings and replacements. Metallic minerals are galena, with blende; chalcopyrite and pyrite, with gold and silver. The gangue is quartz and siderite. These different types of deposits are transitional one into the other, and all are ascribed to hot ascending solutions released from the granitic magma.

These ore deposits are of types similar to those of Western North America, except for the occurrence of tin with the tungsten veins, and have the same genetic relations. J. E. S.

Quin's Metal Handbook and Statistics, 1920. By L. H. Quin. Cloth, 6 x 4, pp. 323. Published by the Metal Information Bureau, Ltd., 7 East India Ave. London, E. C. 3.

This little book contains statistics regarding the price and production of all metals, brought as nearly up to the date of publication as possible. The names of producers and selling agents, the location of reduction works, the grades of product, and the imports and exports of various countries are also listed. The aim is evidently to cover the world, and the book is presumably as complete as any in its field.

Mining in California During 1919—A concise review is given in Preliminary Report No. 6, issued by the State Mining Bureau, San Francisco. The work done by the various operating companies during the year is briefly outlined, and general conditions are discussed.

ECHOES FROM THE FRATERNITY

SOCIETIES, ADDRESSES, AND REPORTS

American Society of Civil Engineers Discusses Improved Highways

The American Society of Civil Engineers held its mid-month meeting on March 17 at the Engineering Societies Building. The subject of the meeting was "The Nation-wide Demand for Improved Highways," and the discussion was opened by H. G. Shirley, who reviewed in a general way the existing highway situation in the United States. The State Highway Engineer of New Jersey, W. G. B. Thompson, supplemented this with an interesting historical sketch of traffic and types.

The chief feature of the meeting was a many-sided discussion of the topic "How Much Can We Afford To Spend for Highways per Mile?" following an introduction by E. J. Mehren, of the *Engineering News-Record*. Points specifically considered covered the permissible cost based on saving in haulage; the need for adequate maintenance, as related to first cost, and the 1920 program of construction.

Robert S. Parsons, chief engineer of the Erie R.R. emphasized the functions of permanent highways as aids to the railroads of the country. The other side of this particular phase is handled in an interesting paper on the development of motor-truck hauling in southern California, published in the *Engineering News-Record* for March 18. The motor lines about Los Angeles, in particular, are competitors of the steam and electric-power railroads.

Vocational and Common-School Training for Mine Workers

A series of bulletins covering numerous occupations is being issued by the Federal Board for Vocational Education. In the bulletin dealing with general mining L. S. Hawkins shows the importance of mining as a vocation and the modern mine worker's great need for a common-school education.

The importance of this problem is shown by the fact that more than a million men in continental United States are employed in its various mines and quarries, and systematic training for those engaged in the industry in such large numbers should be made available, a technical and practical training which will enable them to be more efficient workmen, and to safeguard not only their own lives but those of their fellow men. The selective draft showed that not over 25 per cent of the mine employees could pursue vocational courses requiring as a prerequisite a good common-school education. For a man to secure the maximum benefit from our vocational courses it is necessary for him to have at least the ability to read and write English and to make simple arithmetical calculations.

Increased demand for mine products has made necessary the employment of more men, the working of larger mines, and the operating of lower-grade deposits. It has necessitated the development of improved processes for the preparation of ore and coal, and the introduction of mechanical and electrical appliances in underground and surface operations. Improved machinery, better methods of mining, the working of thinner seams and the problems of mining at greater depths have increased the demand for more highly trained employees.

Vocational training has not kept pace with the growth of the mining industry, but we have reached the stage where we dare not neglect it. Future expansion cannot depend on the addition of raw, untrained immigrants to make up the required demand for labor, but must rely on the training of men for efficient work, and the use of mechanical devices to operate mines successfully. Greater technical and vocational knowledge is needed now than ever before, and the need will be even greater in the immediate future.

Montana Engineers Indorse Hoover for President

The Montana Section of the American Institute of Mining and Metallurgical Engineers, at its annual business meeting on March 5, unanimously adopted the following resolution:

"Whereas, There is at this time a strong and widespread sentiment for Herbert C. Hoover for President of the United States; and

"Whereas, Hoover, by his work in Europe, has shown executive and administrative abilities of the highest order, particularly fitting him for handling both the economic problems of reconstruction at home and our relations with other nations; and

"Whereas, The Montana Section of the American Institute of Mining and Metallurgical Engineers has a patriotic duty to perform at this time, not only as representing engineers, but also as a representative body of American citizens; be it therefore,

"Resolved, That the Montana Section, representing 217 engineers in Montana, indorses Herbert C. Hoover for President.

"Committee on Resolutions,
"RENO H. SALES,
"Chairman;
"CHARLES H. CLAPP,
"NORMAN B. BRALY."

American Zinc Institute's Tri-State Section Promotes Community Welfare

The Tri-State Section of the American Zinc Institute was chartered in the spring of 1919 and comprises members of the Zinc Institute active in the Joplin, Mo., Picher, and Miami, Okla., zinc fields. Frank C. Wallower, third vice-president of the institute, is presiding officer of the Tri-State Section. Stephen S. Tuthill, secretary of the institute, recently returned from visiting the Tri-State Section, which he reports to be a very active force in the life of its community. Through the efforts of the section the roads of the district are kept in as good condition as the heavy teaming will permit, the fire hazard is reduced, and a large hospital at Picher is supported. The section has also arranged for vocational training for zinc-mine foremen and department heads under the Smith-Hughes law, to begin April 15. A short address by a man who has something of interest to say to the members usually closes the session. In fact, the Tri-State Section of the American Zinc Institute has developed into a highly constructive community force.

The institute members in the Tri-State territory are enthusiastic as to the progress being made by the institute in its "Make-It-Of-Zinc" campaign, and a large delegation is planning to attend the annual meeting of the institute at the Congress Hotel, Chicago, on May 10 and 11.

Southwestern Geological Society Elects Officers

The Southwestern Geological Society, meeting at Dallas, Tex., on March 19, re-elected Robert T. Hill as president. The other officers were Charles E. Decker and William F. Kennedy, vice-presidents; Ellis Shuler, secretary, and R. B. Whitehead, treasurer. The members of the council are John A. Udden, Jerry Newby, H. P. Bybee, W. E. Wrather, and D. W. Ohearn. Following the meeting the annual dinner was held in the roof garden of the Adolphus Hotel. Among the guests were Ralph Arnold, Dr. I. C. White, and George Otis Smith.

A Bill To Protect Lassen Peak

Volcanologists will be interested in a bill introduced in the House of Representatives on Jan. 19 by Mr. Raker, (H. R. 11,890): "For the protection and improvement of the Lassen Volcanic National Park, California, and for other purposes." The bill was referred to the Committee on Appropriations. A similar bill was introduced by Mr. Raker during the first session (H. R. 1120).

THE MINING NEWS

LEADING EVENTS

Iron Country Hoping To Ship Record Tonnage in 1920

More Ore Sold for This Year's Delivery Than Ever Before—Lake Navigation Will Open Late

From present indications it will be a few weeks before the iron ore freighters are moving on the Great Lakes, a late opening of navigation being looked for because of the heavy ice in the rivers and harbors. The last government report, issued a fortnight ago, shows that the average thickness of the ice in the harbors is about 24 in., which is heavier than usual.

Operators are anxious to get started with loading and shipping. More ore has been sold for delivery this year than for any single year in the history of the Lake Superior district. It is estimated that the Oliver Iron Mining Co. will ship over 30,000,000 tons, and that the independents have contracts for a like tonnage, so the shipping record of a few years ago may be exceeded. The railroads which handle the ore from the mines to the docks are getting their rolling stock in shape and are preparing to assemble their crews.

The ore-carrying division of the Great Northern Railroad, with headquarters at Superior, Wis., has placed an order for 1,000 new ore cars and 50 new locomotives. Delivery on the cars is expected to begin about June 1 at the rate of 35 cars per day. The new cars will have a rated capacity of 150,000 lb. and will represent an innovation in ore-carrying practice in that their capacity will be 50 per cent greater than that of the largest ore cars now in service on the Minnesota ranges. The Soo line has also placed an order for 300 50-ton cars for service between the Cuyuna Range and Superior.

There are large stocks of ore at the underground mines, much of which was carried through last season, but it is believed that the stocking grounds will be empty by fall and that almost everything on hand will be sent out. Ore prices have been advanced $1 per ton, while lake freights have gone up 20c. a ton, the new lake rate being the same as for the season of 1918. The new ore price is the highest in the history of the Minnesota ranges and the highest recorded in Michigan since the early eighties. The wages being paid the men are the highest ever known in the district, but at that there is more apt to be a scarcity of labor this summer than a surplus. There are no idle men in the district at present, with only the underground properties in operation, and the pit mines may have difficulty in getting labor.

WEEKLY RÉSUMÉ

Hoover's frank announcement of his candidacy for the Republican nomination was the event most interesting to mining men during the week. In the Lake Superior iron country a record tonnage is anticipated in 1920; navigation is expected to open on the lakes the latter part of the month. In Arizona, the minority stockholders of the Schuylkill Mining Co., of Chloride, failed in their application for an injunction and a receivership. In Nevada, the public service commission has been asked to secure lower freight rates on iron ore shipped from the Brunswick district to the Pacific Coast. In Colorado, a contract has been let for building a 30-mile railroad from Craig to Mt. Streater. In the Joplin-Miami zinc-lead district, extensive prospecting is being done by three large companies in a new field 10 miles south of Joplin. In British Columbia, amendments to the Placer Mining Act have been introduced in the Legislature. In Nicaragua, the Nicaragua Mining Co. plans to enlarge its Bonanza mill.

News from Washington is to the effect that prompt action on the new War Minerals Relief bill is extremely unlikely. The Alaskan Engineering Commission has been given the task of building up business for the new Government road.

More Miners Needed in Utah Camps

A shortage of miners is making itself felt in Utah, and particularly, it is said, at Park City. The plan of training unskilled workers to become miners, the only requirements for training being intelligence and a speaking knowledge of English, has been proposed as a way to meet the difficulty. Possibly the state school of mines may co-operate with the employers in this work. The men in groups of twelve could be placed in charge of a shift boss, who would instruct them in handling tools and in the rudiments of practical mining. Wages would be paid in proportion to the work done as compared to that done by skilled labor. In the beginning this would be somewhat less than normal wages, but would increase as the work improved.

Nabob Consolidated Mill Placed in Operation

The 150-ton mill of the Nabob Consolidated Mining Co., on Pine Creek, in the Cœur d'Alenes, is now in operation. It was practically completed last fall, when the company became embarrassed financially and all work was suspended until about Feb. 1, when arrangements were made to pay off the indebtedness of the company and provide funds for resumption. The mine is reported in condition to keep the mill running at capacity. The ore carries both zinc and lead, but the company will confine present shipments to lead concentrates.

Hoover Frankly a Candidate for Republican Nomination

Will Make No Personal Canvass and Does Not Wish To Be Entered in Preliminaries

Herbert Hoover is now openly in the race for the Republican nomination for President. In a statement sent on April 3 to Hoover Republican clubs throughout the country Mr. Hoover dispelled all doubts regarding his position with respect to political parties. The statement follows:

"I shall be unable to take part in a personal canvass, as my administrative obligations to several organizations engaged in the starvation relief in Europe are such until their next harvest that I can give but little time to any other matters.

"After the refusal to allow my name to be put into the primaries hitherto at every place where I have been consulted, so far as I know it has only been done in the states of California and Michigan and in one solitary district outside. As there is little organization on my behalf except the clubs that have sprung up spontaneously over the country, and as most of the primaries are closed and at this date no organization is possible that could compete with other organizations, I do not consider my friends will find any advantage in that direction in other primaries. Those who think I should be nominated will, I believe, find their energies better applied to promotion of their views to the country and the delegates already named, with full respect to their prior pledges.

"I had no expectation that my entrance into this situation would be welcomed by a type of person who conceives that fitness for office, patriotism and citizenship depend upon placing sheer partisanship above national interest or who require years of demonstrated participation in work with mechanical politicians. I cannot assist these people by trying to prove that I belong to their class.

"Some people of this sort feel great trouble of mind that in a letter addressed to a friend last year I expressed my alarm at the then growing partisanship and pressed the need for unity of action between the legislative and executive branches of the Government, while we were still faced with the problems of war. It was obviously my duty as an important war official to support the President without thought of any political interest to myself from the day I entered the Administration until I left it, and I put no qualifications upon or apologies for loyalty to one's chief in office.

"On the second point of their anxiety I make no pretension to a great record of partisan activity. I at once admit that my political interest was confined to membership in a prominent Republican club and allegiance to the party over years, but I earned my living in one of those professions that required so intermittent a shift of residence from my home base as to preclude my taking such a part as I should have liked in the privilege of every citizen at the polls.

"At least, no one can find political expediency in these things, so that to all those voters who believe that they comprise the basis of choice before the party convention I wish it said at once that I make no pretence to come within the limits of their requirements.

"The purpose of the political parties, as I see them, is to organize team work for the advancement and consummation of their views on the issues and measures that are before us and the securing of men in public office who will give execution to these issues and measures. Therefore, I trust, first, that the men and women who do me the great honor to advocate my name will bear in mind that personal criticism of the other names before the party is chiefly of service to the opposition. All these men are patriotic, honorable Americans. They have all served the country well and are entitled to respect.

"Second, I trust I shall not be further embarrassed by suggestion of some independents of the alternative of placing my name before any other party, for a primary sense of team work in any party organization would preclude such a possibility.

"I presume that the various clubs that have been formed over the country will need to expend a certain amount of money on printing and other incidentals, but I trust that each and every one of them will confine itself to minor subscriptions and minor expenditures and will be prepared to open its books to public inspection."

Kirkland Lake Gold Report Disappoints Stockholders

The recent annual report of the Kirkland Lake Gold Mines for the year ended Dec. 31, shows an average recovery of only $4.97 a ton. These results are extremely disappointing to the shareholders, as they were given to understand that the ore reserves would average $8 to $10, and, in addition, the reports regarding the rich discovery made some months ago led them to believe that these results would be considerably exceeded. No information is given regarding the average extraction, and one is forced to the conviction that either the reports of the new ore have been greatly exaggerated, or, if it is as good as claimed, the average tenor of the developed ore is very low. The Kirkland Lake Gold is controlled by the Beaver, which has had it under operation for several years. To date, the information supplied regarding it is remarkable only for its paucity.

Court Refuses Injunction Against Schuylkill Mining Co.

Minority Stockholders' Plea for Receiver Denied in Action Brought at Kingman, Ariz.

BY S. FORD EATON

A case of some interest has just been tried in the Mohave County superior court at Kingman, Ariz., before Judge Bollinger. Action was brought against the Schuylkill Mining Co., its directors and Frank A. Garbutt by C. A. Burke and other minority stockholders.

The company owns the Tennessee and Schuylkill mines, in the Chloride district, the former being the most important mine in the camp. In refinancing it was necessary for the company to grant concessions of much importance. These concessions were objected to by Mr. Burke, who brought suit to have the contract set aside and for the appointment of a receiver.

On March 26 the case was submitted to the court. Judge Bollinger, in consideration of the evidence introduced, refused to grant an injunction and appoint a receiver. Further action may take place.

It appears that the directors had full authority, granted at a meeting of the stockholders, to enter into a contract for further financing and that a binding payment on the contract had been made. The main feature of the new policy is the building of a mill, the start of which has been somewhat delayed. The complaining witness in the suit stated that there is a considerable tonnage of ore in the Schuylkill and Tennessee mines, the value of which will warrant shipment to a Yavapai County mill for the separation of the lead and zinc; the mill products then to be shipped to lead and zinc smelters at a considerable profit. It was further claimed that the property had been wilfully mismanaged with an ulterior motive.

Many witnesses were called and much testimony foreign to the real issue was given. Summed up, the case hinged on whether or not the ore in the mines is of sufficiently high grade to stand the cost of shipment to a foreign mill and thence to smelters, with the various accompanying charges. It developed that the cost of shipping to the mill proposed by Mr. Burke would be about $4 per ton, with approximately a similar milling charge. In addition there would be the shipment and treatment charges in connection with the smelting of the mill products. The total cost against the raw ore seems prohibitive in view of the values shown to be in the ores.

The intention of Mr. Garbutt and the new interests is to carry on active development along conservative lines.

The Canadian Minister of Finance has introduced a bill at Ottawa to reduce the fineness of Canadian silver coins from 935 to 800 parts per thousand to forestall melting Canadian coinage.

B. C. Placer Mining Amendments Change Rentals

Will Permit Payment of Arrears in Instalments—Seek To Release Areas Now Tied Up

BY ROBERT DUNN

In the proposed amendments to the Placer Mining Act of British Columbia, which has been presented to the Legislative Assembly by William Sloan, Minister of Mines, changes are made in rentals and development work as follows:

Hydraulic lease, $25 in place of $50 per annum and development $250 instead of $1,000 per annum.

Creek lease, $37.50 in place of $75 per annum and development $250 instead of $1,000 per annum.

Dredging lease, $25 in place of $50 per mile and development $250 instead of $1,000 per mile per annum, the value of any new plant or machinery employed to count as money expended on development; and 50c. royalty to be charged against every ounce of gold recovered.

Provision has been made for the elimination, by easy stages and in an equitable manner, of the accumulated arrears of rentals on placer mining leases, these now being estimated as approximating $350,000.

The framing of the remedial treatment has been given Mr. Sloan's careful attention, it being necessary to guard the rights of the license holder who has invested heavily in development and contemplates further development, but has been temporarily embarrassed financially. But it is also necessary to assure that ground tied up by leases that are likely to continue inoperative shall be thrown open to others anxious to work it.

The provisions of the new legislation may be summarized as follows:

In respect of leases now in arrears for more than one year's rental the lessee may apply before Jan. 1, 1921, for the consolidation of the annual rentals in arrears and arrange for their payment by annual instalments extended over a period not exceeding ten years. Where the arrears are consolidated the failure to pay the annual instalment or the current annual rental when due will automatically result in a forfeiture of the lease. Where the lessee so in arrears fails to apply for consolidation and fails to pay the arrears before Jan. 1, 1921, his lease is forfeited.

After July 1, 1920, leases will be issued at a reduced annual rental and reduced annual expenditure for development work, as has been shown. Leases in this new form will contain a provision for automatic forfeiture if the lessee fails to pay the annual rental or to do and record the annual development work. Reinstatement is permitted within thirty days where the fault consisted only of failure to record the work. Excess development work done in any one year may be recorded so as to count on future development work requirements for the following three years only.

In the case of leases in good standing it is provided that the lessees have the option of applying at any time while the regular charges are paid up to have the annual rental and annual expenditure reduced to the rates under which new leases are to be issued after July 1 this year. If they apply and obtain this reduction, the conditions of automatic forfeiture for default, and the privileges of recording excess work and paying cash in lieu of work, which are applicable to new leases, will also attach to these old leases. If they decide not to apply for a reduction of rental and annual expenditure their leases will continue subject to the same provisions as at present.

Leases which become in good standing through consolidation of arrears may also be brought under the reduced rates of rental and other provisions applicable to new leases issued after July 1.

There is yet another innovation of importance. Heretofore placer mining leases have been issued by the Gold Commissioners, who have their headquarters at different central points throughout the province, with the sanction of the Lieutenant Governor in council, the authority to issue the same being invariably based on the Gold Commissioner's report accompanying the application. It is now proposed that Gold Commissioners, having full knowledge of all local conditions, shall be empowered to issue such leases without reference to the Lieutenant Governor in council while, as has been indicated, automatic forfeiture is provided for in cases where the lessee fails to observe the conditions of his lease.

The basic reason for these alterations is the recognition that, at least in so far as the long-exploited placer fields of British Columbia are concerned, the methods of the individual miner have given place, for the most part, to those of the hydraulic or dredge operator. As the latter have contributed materially to the arrears indicated, it is felt that a reduction in both rental and development rates will have the effect of stimulating and stabilizing the placer mining industry of British Columbia.

Contracts have been let covering all the equipment necessary to the doubling of the smelting capacity of the United Zinc Smelting Corporation's plant at Moundsville, W. Va. Excavations for foundations have already been started. Completion is anticipated about Oct. 1, when zinc production will amount to 100,000 lb. or more per day. The Moundsville plant is also a producer of 60-deg. sulphuric acid, production at the present time amounting to about 120 tons per day.

At the Manhattan mine, near Picher, Okla., the company is changing from steam to gas power, which will reduce working costs, and a much greater production is expected. An exploration campaign is being conducted, leases are being procured, and drills are already in operation.

Nationality Poll of Employees Taken by Oliver Mining Co.

U. S. Steel Subsidiary Finds 60 Per Cent Are Citizens and 16 Per Cent Have First Papers

The Oliver Iron Mining Co., the mining subsidiary of the U. S. Steel Corporation, has announced a nationality poll of its employees in the Lake Superior district. The poll is as of November, 1919, and shows that of the 12,266 employees 7,436 are American citizens, 2,072 "first-paper" citizens and 2,758 aliens. Below are details by ranges:

NATIONALITY POLL OF OLIVER IRON MINING CO.'S EMPLOYEES

Range	Full Citizens	First-Paper Citizens	Aliens	Total
Mesabi	3,738	979	1,848	6,565
Vermilion	437	171	125	733
Total Minnesota Ranges	4,175	1,150	1,973	7,298
Marquette	433	39	51	523
Gogebic	1,491	634	625	2,750
Menominee	1,337	249	109	1,695
Total Michigan Ranges	3,261	922	785	4,968

Under full citizens are listed both native-born and naturalized. Among those listed as first-paper citizens and aliens are representatives of practically every European nationality, but principally Finns, Austrians, Italians and Croatians. Similar classifications have not been issued by the independent mining companies, but the proportions may be considered approximately the same. The Government, the municipalities, the school districts and the employers are now combined in an intensive campaign for the naturalization of all aliens in the Lake Superior district. Very satisfactory progress is being made.

Drilling for Ore in New Field South of Joplin

Extensive prospect drilling is being carried on by three companies, the Eagle-Picher Lead, the American Zinc, Lead & Smelting, and the Underwriters Land Co., on lands located about ten miles south of Joplin as a result of rich finds made on the Winchester farm in that locality several months ago. The strikes were made by the American Zinc Co., and seem to indicate an entirely new field. The formation is found at about 270 ft. depth, and extends down to about 350 ft., which is deeper than mining has ever been carried on in this section. So far, no strikes of importance have been made outside of a comparatively small area, though it is only within the past few weeks that drilling over an extended area has been begun. The Eagle-Picher Co. has placed several drills at points about half a mile apart on a lateral line, which was the style of drilling by which they discovered the rich formations in the Picher, Okla., camp, and the Underwriters Land Co. is using the same method. The fact that three such strong companies are participating in the prospecting work is considered as assuring rapid development of the new field should drilling results justify.

Geologists Leaving Canadian Survey for Private Work

Eight Out of Twenty-One Have Resigned—Legislative Assembly at Victoria Proposes Remedy

So serious are the probable results of the withdrawal of many of Canada's best-known young geologists from the service of the Geological Survey of Canada to take commissions at increased salaries with private concerns that the matter has been taken up on the floor of the Legislative Assembly of British Columbia. When this province entered into the Canadian confederation one of the stipulations was that the Dominion government should undertake a geological survey within its borders. This has been carried on satisfactorily, though slowly, up to the present, but it has become apparent that the failure to provide competent geologists with income sufficient to justify their remaining in the service is almost certain to cripple the staff so that it will be impossible to undertake more than a small proportion of the work that had been planned for this year in western Canada. Completion of the program must be deferred.

William Sloan, Minister of Mines, presented a resolution to the provincial legislature enumerating these and other points in this connection recently. Out of twenty-one geologists available for field work throughout the Dominion eight had already tendered their resignations and others were likely to do so. As the Geological Survey had maintained an average of nearly twelve geological and topographical field parties in British Columbia alone prior to 1914, it was evident that the depleted staff could not meet requirements, the work undertaken not having been more than well begun.

Among the suggestions that the legislative assembly will make to the Canadian Government—for there is no doubt that the resolution will carry—are the following:

"To offer adequate inducements to engineering and scientific students of Canadian universities to undertake training with a view to employment on the Geological Survey of Canada.

"To complete and publish the results of the geology of such districts as have been topographically mapped.

"To adopt a policy assuring the maintenance on an adequate basis of the work of the Geologcial Survey of Canada in British Columbia, to the end that the letter and spirit of the terms of the 'British North America Act' may be implemented and the development of British Columbia expedited."

"Mass" Copper's Role in Northern Michigan

Has Helped Production Record Greatly at Number of Mines—Isle Royale Yields Most

BY HOMER A. GUCK

Mass and barrel copper, so called, have played a very important part in the productivity of Lake Superior district copper mines from the very earliest days. Today they are an important feature in the output of the Quincy and Isle Royale companies.

When Dr. Douglass Houghton, the eminent geologist, first visited this northern section, in company with General Lewis Cass, in 1830, 90 years ago, he was impressed with the "float" copper that he stumbled on in many places. It did not impress General Cass. But Dr. Houghton spent a great deal of time and effort in the state legislature and finally secured a small appropriation from the commonwealth to make a geological survey. His report was printed in 1841. He mentioned, in a matter of fact way, the numerous surface evidences of copper veins and mass copper.

Three years later the government issued permits for the first work and it was due to this float copper that the permits were given on the basis of returning 20 per cent of the gross production to the government and that the permits were so generous in their extent of territory, nine miles square being the amount of surface given to each applicant. This did not work, because the men who secured the rights did not give the government any of the copper they found and there was constant difference of opinion regarding the limits of claims.

In the territory that now is Keweenaw and Ontonagon counties there was the greatest activity and much of it was directed toward the location of mass copper. Such veins as were opened were followed more for the mass and barrel copper than for the distinctive vein matter. And the mass copper served as a valuable advertisement for the Michigan copper district in those early days.

From that day to this, notwithstanding the fact that dividends and wages have been paid out of vein matter, to a large extent, the mass and barrel copper has in a number of mines assisted materially in fattening the production record.

In some of the smaller mines, such as the Mass Consolidated, the Michigan and the Victoria, the mass copper plays an important part. The great mass that was taken from the old National mine continues to serve as a subject for a great deal of argument. The Trimountain and the Ahmeek mines have formations of solid copper extending for level after level. The Champion has a similar solid chunk of copper. All three of these might come under the designation of "mass" copper.

At present the Quincy and the Isle Royale are getting out an unusual amount of this class of copper. There is a difference between the two, however. The Quincy stuff comes in large pieces. Most of it is secured in the lower openings and frequently it has to be cut up in order to get it out of the shaft. Special machinery has been installed at No. 2 shaft to handle this copper. It is sent directly to the Quincy smelter for treatment. The Isle Royale is much smaller, being in chunks about the size of a man's fist. It is termed "head" copper in the mill and comes out in large quantities through the operation of the Krause-Parnall patent water pressure mechanism. More of this grade of copper is secured in the Isle Royale shafts than anywhere else in the district.

Nicaragua Mining Co. Plans To Enlarge Bonanza Mill

The Nicaragua Mining Co., which is operating in the Pis Pis district of Nicaragua, has made its first payment of $20,000 on account of the mortgage of $102,000 against its Bonanza-Mars property. Barry Searle, consulting engineer and general manager, recently cabled that sufficient ore has been developed at these mines to warrant increasing the capacity of the present mill to 120 tons per day. Even under present high costs, the company expects a net profit of $5 per ton. According to the company's construction engineer, G. A. Napoleon, the plant can be rebuilt within four to six months at a cost of $50,000. One-third of it can be put in operation in half this time. This means the Bonanza mill can be earning $200 a day in three months and $600 a day within six months. Later, as earnings warrant, the capacity will be increased to 300 tons per day.

Sinking on the vein will be started at the Concordia mine during April. The ore here runs from $11 to $36 per ton on the average, though better grade is expected on the lower levels.

The office of the company is at 1218 Locust St., Philadelphia, Pa. Benjamin C. Warnick is president; Charles J. Fox, vice-president, and W. H. Steigerwalt, secretary-treasurer. William B. Daniel is general superintendent.

Examination for Engineers and Surveyors in Idaho Announced

The Department of Law Enforcement of Idaho announces that the next regular examination for engineers under the Idaho Engineers Law will take place in the Capitol Building at Boise, Idaho, on Sept. 14. The examination for surveyors will be given in the same place on Sept. 7. All communications should be addressed to the department at Boise. Robert O. Jones is commissioner in charge.

The Utah Leasing Co. is not a subsidiary of the Western Metals Co. as stated on p. 719 of the issue of March 20. The mill which is being moved to Shirley, Col., comes from Newhouse, Utah.

Manitoba, Canada, Legislates Against Wildcat Promotions

Amendments to the Sale of Shares Act passed by the Manitoba Legislature embody similar provisions to those in force in Ontario for the protection of the public against the promoters of wildcat mining enterprises. No company is to receive a certificate legalizing the sale of its stock until a prospectus has been filed showing the amount paid for the property, amount of vendors and treasury stock, names of directors, description of property, and other information indicating the standing of the enterprise, and all advertising must strictly conform to the facts as set forth. It is thought that this will effectually put a stop to the sale of promotion stock in worthless enterprises, which has done much to discredit legitimate mining investments in Manitoba, as elsewhere.

Dwight & Lloyd Sintering Co. Wins

The U. S. Supreme Court declined to review the case of the American Ore Reclamation Co. vs. Dwight & Lloyd Sintering Co. In calculating royalties, the American Ore Co. made settlement on the basis of 2,240 lb. to the ton. The Dwight company claimed that settlement should be made on the basis of 2,000 lb. to the ton. It also claimed that the statutory ton in New York, which is 2,000 lb., must apply. The American Ore Co. contended that the statutory ton applied only to certain classes of contract. The District Court upheld the ore company, but the Circuit Court, whose decision now stands, reversed the judgment.

Recent Production Reports

Phelps Dodge Corporation's smelter at Douglas, Ariz., produced 7,931,000 lb. of blister copper in March as follows: 5,355,000 lb. from Copper Queen, 1,786,000 lb. from Moctezuma Copper Co., and 790,000 lb. from custom ore.

Practically every mine in the Michigan copper district increased its production of "rock" in March over that of February. The total of the district continues 60 per cent of normal.

Osceola produced 50,000 tons of "rock" in March, compared with 49,000 in February. Of this 12,000 came from the old Osceola mine and 38,000 from the Kearsarge branch.

Ahmeek produced 68,000, a little less than in February.

Centennial produced 7,000 tons in March against 6,525 tons in February and 7,500 in January.

Allouez showed a substantial betterment in March, increasing from 14,231 tons in February to 20,500 tons in March.

Isle Royale kept her own three-head stamp mill running full time in March and sent 2,880 tons to the custom mill in addition.

Superior got out five carloads and La Salle ten carloads, all from development work.

NEWS FROM WASHINGTON

By PAUL WOOTON
Special Correspondent

Zinc Men To Be Heard on Behalf of Two-Cent Tariff

Senate Committee Will Listen to Plea For Rate Higher Than Provided in Present Bill

The demand for a two-cent tariff on zinc has become so strong that the Senate committee has decided to hear some of the proponents of the higher rate of duty before actually reporting the bill to the Senate. As passed by the House, the bill provides that zinc-bearing ore containing 25 per cent or more of zinc is dutiable at one cent per pound. Strong representations have been made since the Senate committee ordered the bill reported, that the rate of duty provided is too low to be of benefit to the domestic industry. Senator Spencer, of Missouri, is leading the fight for the two-cent rate and has the support of Senator Watson, of Indiana, chairman of the sub-committee handling emergency tariff legislation.

Federal Board Reports on Non-Ferrous Metal Situation

Comment on the non-ferrous metal situation, as a result of reports to the Federal Reserve Board, is to the effect that zinc and lead are being shipped heavily from the Missouri and Oklahoma producing districts, at somewhat lower prices for zinc than prevailed Jan. 1, but with the lead ore commanding higher prices. The movement of these ores, however, is being limited by car shortage. The board reports that labor conditions are improving in the metal mining regions of Colorado and that many new operations are being started, especially in the silver mining section. Speaking generally on the labor situation, the board says:

"There is a substantial degree of harmony between capital and labor as indicated by the small amount of unemployment and labor controversy now in existence. The difficulties in sight are due to conditions of relative underproduction or decrease of production resulting from lessened activity of capital and labor, problems arising out of heavy taxation and measures resulting from the one-sided working of present tax laws, while financially speaking, caution and conservatism are called for and the efforts to restrict the volumes of credit, which thus far have been made, have been only partially successful. As a result, high interest rates and relative scarcity of funds will continue to prevail during the period in which the country is endeavoring to extend its productive facilities and to overcome the relative loss of progress, resulting from war limitations upon investment and production."

House Leaders Oppose Early Consideration of New War-Minerals Relief Bill

Measure at Present Buried—Failure To Consider "Request-and-Demand" Feature of Present Law Disapproved by Some—Claimed Existing Act Allows Property Payments

Opposition on the part of leaders in the House of Representatives makes it appear improbable that any early consideration will be given to the bill authorizing a review by the Court of Claims of awards made under the War-Minerals Relief Act. The objection on the part of Congressional leaders is based largely on the ground that it would add materially to the expense of disposing of war-minerals claims. If the Court of Claims were authorized to review these cases, it is declared, it would be necessary for them to employ engineers, accountants and other experts so as to make their own investigation of the merits of each case appealed to them. In addition to the added costs, objection also is made on the ground that the additional appeal would greatly extend the time that would be required for settling up these cases. It is the desire of the Congressional leaders that the cases be disposed of at the earliest possible time.

Representative Wingo, of Arkansas, the ranking Democrat on the committee, and one of the chief exponents of the bill, is indignant at the action of the leaders and declares it is entirely unfair to deny to war-minerals claimants the privileges which are extended in the same statute to War Department claimants.

Representative Garland, the chairman of the Committee on Mines and Mining, is very anxious to have the House consider the bill, but has bowed to the inevitable, as he realizes that the measure is effectively buried in its present position on the unanimous consent calendar and that it will require a special rule to secure its consideration by the House. Since the Rules Committee is in accord with the leaders, the chances of early consideration are small.

The discussion of the War-Minerals Relief Act, which has been occasioned by the steps taken to supplement it with further legislation, reveals the fact that certain verbiage was placed in the law with the evident intent of being interpreted so that the appropriation could be used to reimburse payments for mining properties. It will be recalled that the provision providing for property payments was struck out by the Senate, but as agreed to in conference the law provided that "no claim shall be allowed or paid unless it shall appear to the satisfaction of the said Secretary, that the expenditures so made or obligations so incurred by the claimant, were made in good faith for or upon property which contained either manganese, chrome," etc. It seems to have been the intention on the part of some of those concerned in the drafting of the act, that expenditures "for" or upon property would be interpreted to include payments made for properties. The failure of the War-Minerals Relief Commission so to interpret the law has been very disappointing to some of those who have been seeking the liberalization of the war-minerals statute.

STATUS OF PENDING MINING LEGISLATION

Bills That Have Reached Committee Stage

Subject of Bill	*Bill No.*	*Author*	*Present Status*
Silver in coins	*H.R.* 11,226	*McFadden*	*Before House Committee*
Met. Min. on Ind. Res.	*S.* 287	*Ashurst*	*On Senate Calendar*
Timber for mining purposes	*S. No.* 1	*Pittman*	*Passed Senate Oct.* 3, *before House Committee*
Anti-dumping	*H.R.* 10,918	*Fordney*	*Passed House Dec.* 9, *before Senate Committee*
Laboratory glassware	*H.R.* 7,785	*Bacharach*	*Passed House Aug.* 2, *on Senate Calendar*
Magnesite	*H.R.* 5,218	*Hadley*	*Passed House Aug.* 7, *on Senate Calendar*
Tungsten	*H.R.* 4,437	*Timberlake*	*Passed House Aug.* 21, *on Senate Calendar*
Zinc	*H.R.* 6,238	*McPherson*	*Passed House Sept.* 2, *ordered reported favorably*
War Minerals Relief	*H. R.* 13,091	*Garland*	*Reported favorably to the House March* 25.

The new bill as decided upon by the Committee on Mines and Mining does not meet the approval of many claimants, because of the fact that it does not take care of the "request and demand" feature of the existing law.

While the members of the War-Minerals Relief Commission admit that a considerable number of the letters received by the commission are brickbats, now and then a bouquet finds its way to its offices. Recently the commission made an award, which was one-third of the amount of the claim. In acknowledging the receipt of the decision the claimant wrote: "We will accept the award without comment or protest, as we feel that it is entirely just and most fair in every respect. Speaking for my partner and myself, I wish to say that our treatment by the commission has been most considerate, courteous and gentlemanly in every way, and we wish to express our appreciation."

Awards made by the commission during the week ended March 27 were as follows: Barton and Cain, $1,229.99; H. L. Flournoy, $996.46; I. O. Jilson, $1,235.30; C. M. Anderson, $663.74; C. H. Hawkins, $920.41; Grants Pass Chrome Co., $4,921.43. The awards made represented 35 per cent of the amount asked in the claims. All of the claims handled during the week were chrome, except the Anderson claims, which covered a manganese operation.

Geographic Society's Daly Medal Awarded to George Otis Smith

The Charles P. Daly gold medal, which is awarded from time to time by the American Geographic Society to explorers, writers and men of science who have contributed to the advance of geographical knowledge, was awarded to Dr. George Otis Smith, director of the U. S. Geological Survey, in New York, on April 6. The medal bears this inscription: "To George Otis Smith, Director of the United States Geological Survey. He helped disclose and develop the natural resources of his country, adapting them to its service in peace and war."

President Greenough of the society, in making the presentation, called attention to the fact that Dr. Smith long has been a leader of thought in the industries which his bureau serves. He brought out, however, that the award is also a public recognition of work done by such lieutenants of Dr. Smith as: Dr. Alfred H. Brooks, Robert B. Marshall, C. H. Birdseye, Glen Smith, J. W. Bagley, J. B. Umpleby, E. S. Bastin, L. L. Lee, J. H. Wheat, A. T. Fowler and Kostka Mudd. The Daly medal has been awarded to Arctic explorers, Perry, Amundsen and Stefansson, and to other geographers, including two members of the U. S. Geological Survey, Prof. G. K. Gilbert and Alfred H. Brooks.

Business for Alaskan Railroad Object of New Bill

Following the report of the Secretary of the Interior to the effect that he had no authority to take adequate preliminary steps looking to providing traffic for the Alaskan Railroad, Senator New, of Indiana, chairman of the Committee on Territories, has introduced a bill authorizing the Alaskan Engineering Commission to do whatever it deems necessary to provide business and traffic for the railroad, and to promote the development and settlement of its tributary territory. Such funds as may be needed for this purpose are to be taken from the appropriation made for building the road.

Secretary Payne, however, realizes that the road must look to the mining industry for the great bulk of its tonnage and immediate efforts are to be centered on the stimulation of mining industry in the territory tributary to the railroads.

NEWS BY MINING DISTRICTS

ARIZONA

Dundee-Arizona Resumes Pumping and Sinking—Molly-Gibson-Chloride Property Under Development

Miami—There is local confirmation of the sale of the Porphyry property to its neighbor, the Inspiration. The Porphyry has stopped drilling. Inspiration has closed its experimental leaching plant.

Miami Copper's crushing plant will be of concrete, 90 x 143 ft., and there will be a modern change house, 62 x 116 ft. Bids have been called for for these and for a sampling plant, all to be completed within 100 days.

Superior & Boston has opened up the stopes closed by the mine fire of last July. The fire is out and the air good. The workings are badly caved and the timbers of the affected section are gone. Drifting is being pushed on the 600 to get under the rich ore found 200 ft. above, and the same vein is being approached on the 800 level.

Jerome—Dundee-Arizona has been doing no sinking for several months, suspension being due to an inrush of surface water from a shattered vein. The water level now stands at 600 ft. The rainy season being considered at an end, pumping is to be resumed; the 830-ft. shaft is to be extended to 950 ft. and a drift run northward to the contact, where there is confidence an orebody will be developed. Shipping from the 5-per cent carbonate surface capping has been stopped temporarily.

Jerome-Superior has a new 625-ft. compressor, added to older equipment of compressors of about 1,000-ft. capacity. A 6-in. water column has been added to the 5-in. main already in the shaft and a new pump added on the 700 level. The main shaft is being deepened from 750 ft. and two diamond drills are operating on the 700 level.

Bisbee—The fire which broke out March 27 on the 1,300 level of the Briggs mine of the Calumet & Arizona company is reported under control.

Winkleman—The Dripping Springs Copper Co., operating the old John Reed property in the Dripping Springs wash northeast of Troy, has cut a 22-ft. vein in the face of the long crosscut tunnel. This discovery was made 500 ft. below the surface. The vein assays well in copper for its full width and will furnish considerable shipping ore. C. H. Gowman is in charge.

Chloride—Active development is well under way at the Molly-Gibson-Chloride property. Equipment consists of a 25-hp. 10 x 10-in. Fairbanks-Morse gasoline hoist, Sullivan compressor and pump. A new 30-ft. headframe was recently completed. The double-compartment shaft is now down 80 ft. and will be carried to the 200-ft. level. At that point a 250-ft. crosscut will be driven to the vein. R. C. Fergusson is in charge.

ARKANSAS

Rush—Miners at the Beulah zinc mine cleaned out a shaft sunk 20 years ago and discovered a forgotten orebody at the 30-ft. level.

J. C. Shepherd had started work on the Mackintosh and Monte Cristo mines. The latter produces carbonate and jack and has a large body of both kinds of ore developed. Con Medley is in charge.

A rich strike of carbonate was made at the Mattie May mine at Rush recently. The extent of the orebody has not been determined. The property has a 100-ton mill.

Zinc—The mill at the Salina mine, seven miles northeast of Zinc, is operating satisfactorily. It is equipped entirely with tables—the only one in the camp of the type.

CALIFORNIA

Bulkeley Wells To Start Hydraulic Mining at Brandy City

Masonic—A. G. Cook and eastern associates have bought the Pittsburg-Liberty mine at Masonic, Mono County, Cal., from P. J. Conway, of Reno, for $32,500. The first payment of 25 per cent has been made and the balance is to be paid in instalments.

Brandy City—Hydraulic mining on a scale unknown in this vicinity in recent years is expected to be started soon at Brandy City, Sierra County, by Bulkeley Wells and associates, who have acquired the gravel properties. The same

interests have taken over the Marysville-Nevada Water & Power Co., which built a large concrete impounding dam at Bullard's Bar, on the north Yuba River. It is said that the dam is to be raised 10 ft. The Marysville-Nevada company will be known in the future as the Yuba Development Co., with headquarters in San Francisco.

Oroville—Pacific Gold Dredge No. 4 is being overhauled and remodeled at the Indiana Machine Shops. It will be shipped to the Malay Peninsula to be used in tin dredging.

Angel's Camp—At the Lightner mine the shaft has been unwatered 360 ft. below the collar, leaving 140 ft. yet to be baled out. Over a million gallons has been handled daily by skip. It is estimated that the work will take two months more. Surface improvements being made will be completed when active development is started.

Campo Seco—The Penn Mining Co. has closed its smelter to develop ore. When the price of copper was high reserves were heavily drawn upon. Up to March 1, 200 men were employed. This force has been reduced to 75.

Slate Range—The Ophir-Inyo Mining Co. has been organized by Kellogg Van Winkle, of San Francisco, to take over the Ophir mine in the Slate Range Mountains, Inyo County, and the first shipment of silver-lead ore has been sent out by the new owner. The Ophir has been operated by J. A. Otto, of Los Angeles, and produced a substantial tonnage during the war period. The formation is the same as that on the Slate Range Minerals Co.'s property.

COLORADO

New Company Formed To Operate Enterprise at Gunnison—To Build Railroad From Craig to Mt. Streeter

Durango—Operations at the Cumberland mine have been suspended until the roads can be cleared from recent heavy snow.

The Jumbo is sending out from 4 to 6 cars of ore each month from a new orebody.

Lessees on the Idaho, who began work late last year and have been driving a tunnel to open up possible orebodies in the old workings, have discovered sylvanite in the La Plata sandstone which carries high values in gold and silver. Ore is being sacked running over $3 per pound. This is said to be the first instance of sylvanite being found in the La Plata sandstone.

Ouray—The Portland mine, long idle, is being operated by the Colorado-Zanett Mining Co., John Zanett, manager. Development of a streak of good ore is going on with encouraging results. The property is poorly financed and work has been done only by hand. Recent developments indicate the possibility of sufficient capital being provided and the company is figuring on necessary mining equipment. It has also taken an option on the Gold Crown mill and mines in Ouray with the idea of using the mill for treating its Portland ore.

Gunnison—Business and mining men of Aspen have organized the United Silver M. & M. Co. to operate the old Enterprise properties in Taylor Park, which have been worked at intervals for the last forty years but under disadvantages on account of altitude and distance from railroad.

Craig—A contract has been let for the construction of 30 miles of railroad extending from Craig, Col., the present terminus of the Moffat road, to Mount Streeter. It is said that the Mount Streeter Co. will extend the road to the Utah line, there to connect with the line projected by Gov. Simon Bamberger of Utah, which is to extend from Provo, Utah, to the Colorado line. Mount Streeter is a coal town supported by the semi-anthracite coal mines in the vicinity.

Lake City—The Colorado Cons. M. & M. Co. has almost completed work on the dam and pipe line for its power plant. The old mine workings have been cleaned out preparatory to development. The chlorination mill built 25 years ago is to be replaced by a concentration and flotation plant.

Rico—The Wellington company, after spending a year or more in driving for the orebody, has cut a 3-ft. vein of lead-carbonate ore which is now being mined for shipment. The new body was in virgin territory and appears to be in a blanket formation, the sides not having been disclosed in over fifty feet of drifting. A new loading terminal and equipment for the tramway will be installed as soon as possible.

The Detroit-Colorado and the Coming Wonder are increasing shipments. The latter property is operated by lessees.

The Emma, recently taken over by the Dolores Silver Mines Co., Inc., is being developed and high-grade ore stored for shipment when the trails are passable for pack-trains. Twenty miners are developing and blocking out and mining ore for the flotation plant which will be completed when weather permits.

Central City—The Black Jack mine in Silver Gulch, operated by the Silver Mountain Mining Co. of Denver, recently shipped a car of ore to the Pueblo smelter, which was settled for at .078 oz. gold, 152 oz. silver, and 21 per cent lead.

IDAHO

Stewart Mining Co. To Prospect for Faulted Orebody.

Wallace—The Stewart Mining Co. has had a thorough geological investigation made of the ground east of the fault which cut off the ore shoot several years ago and forced a shutdown. It is planning to begin work soon in the hope of finding the orebody east of the fault. The company for many years was one of the big lead producers and dividend payers of the district.

The Mullan Leasing & Development Co. is shipping at the rate of six carloads of concentrates per month, running 35 per cent lead and 60 oz. silver. It is working the old Ontario tailings dump near Kellogg and is milling about 200 tons per day.

MICHIGAN

C. & H., Quincy and Copper Range Shipping Copper by Rail Steadily

Houghton—Two cars of copper are going out daily from the Calumet & Hecla plant at Hubbell. The Quincy and Copper Range companies are both shipping an average of one car a day recently. The shipments would be larger were it possible to get more cars.

Franklin has opened a stretch of ground in the 39th level that is expected to run better than 25 lb. per ton.

Calumet—Seneca will start shipping to the Baltic mill within 30 days, clearing up remains of the stockpile and handling ore from development work in the main shaft. Concrete work in the shaft was completed April 1 and the forms have been removed.

At the Gratiot shaft a diamond drill has been set up at the 6th level. It is intended to cut into the Kearsarge conglomerate from this point in the shaft, running to the eastward. This work is being done with the idea of identifying the formation exactly. This Gratiot shaft is bottomed at 1,520 ft. Drifting to the south has started at the 13th level. Sinking will be started in the near future, the plan being to run the shaft down to 3,200 ft. before starting the lateral to connect with the Seneca.

MINNESOTA

Mesabi Range Operations

Coleraine—Stripping operations will begin on the Bovey-Judd property of the Oliver Iron Mining Co. as soon as conditions permit. The overburden is estimated at 2,500,000 cu.yd. Butler Bros. have the contract.

Buhl—Two horizontal tubular boilers are being installed at the Grant mine of the Interstate Iron Co. for sinking and operating a pumping shaft. The Grant is an isolated open pit, undrained by adjacent properties, and the pumping shaft is made necessary by the lower loading levels to be used this season.

Eveleth—Work has started on remodeling the old Fayal hospital into apartments for employees of the Oliver company.

Relining old No. 1 shaft at the Leonidas mine has been completed. The new lining is concrete and is bottomed at 448 ft. Steel ladders and sollars are now being put in place.

Cuyuna—The Arko Mining Co. has sold a large tonnage of manganiferous ore to the Steel & Tube Co. of America for delivery in 1920. The ore is sold on a guarantee of 39 per cent natural iron, 0.3 per cent phosphorus, 7 per cent silica and 11 per cent manganese. The price reported is $7.20, f. o. b. Chicago.

MONTANA

The Butte District—Galt Mining Co. in Cascade District May Resume

Butte—Anaconda engineers are looking forward to cutting the Orphan Girl, the Anglo Saxon and the Orphan Boy veins on the 1,000-ft. level of the Orphan Girl property, crosscutting for which has started. The Anglo-Saxon vein on the 500-ft. level has disclosed a promising body of silver ore.

The orebody being drifted upon on the 2,700-ft. level of the Colorado mine of the Davis-Daly company continues to hold up in width and grade. A crosscut is being driven on this level for the fissures opened on the levels above and the ground is showing small streaks indicating increasing mineralization. Tonnage is being increased slightly over that of March.

The dip of North Butte's Rory O'More is flatter than was expected and crosscutting for it is taking correspondingly longer.

The grade of shipments for March from Butte Copper & Zinc Co. will approximate 16½ per cent zinc as compared with 13½ in February. The drift on the 1,000-ft. level has progressed more than 280 ft. on the orebody with the ore still continuing.

Cascade District—Plans are under way, it is understood, for a resumption of operations at the old property of the Galt Mining Co.

NEVADA

Operations at Tonopah and Divide—Lower Rate Sought on Iron Ore From Brunswick Section

Tonopah—Operations in the Tonopah district were normal during March. Bullion shipments for the first half were as follows: Tonopah Belmont $111,410, Tonopah Extension $42,000, West End $61,000. MacNamara and Tonopah Mining Co. shipments bring the total to over $250,000.

At the Belmont ore is being obtained from re-working old stopes, and from stopes on the rhyolite veins. Faulted segments and extensions of the principal veins have been developed and furnish the necessary grade.

The Belmont has leased its main sorting-house dump and about 20 lessees and sub-lessees are at work with satisfactory results. Earnings of the Surf Inlet subsidiary for February were $29,865.

The Tonopah Extension has cut the Merger and Murray veins on the 1,780 level. The widths and values are said to be better than on the level above. This is the deepest known ore in the Tonopah district, and possibilities at still greater depth appear good. The company has recently added to its already large acreage by the purchase of the Accidental claim, lying next to the Monarch Pittsburg on the west. Retimbering of the McCane shaft is complete to 540 ft. depth.

The West End Consolidated's mine is reported to be in the best shape of its history. Development of the Ohio vein on the 800 level is progressing satisfactorily. A report to stockholders, dated March 22, states that at the special meeting on Feb. 7, more than two-thirds of the issued and outstanding stock was represented. The plan outlined in the circular letter of Jan. 7 was changed and only two new corporations were organized, the present corporation to continue. Dividend No. 12 was declared on March 20, for the purpose of distributing stock of the newly organized companies, the West End Chemical Co., and the West End Opoteca Mines Co. One share in each of these two companies will be distributed for each share in present company, of record April 2.

The Tonopah Mining Co. is now prepared to treat custom ore at its Millers plant, in addition to its regular mine output, which is about 150 tons per day. The Mandy Mining Co. of Manitoba, a subsidiary, has sold its plant to W. B. Thompson and associates, and after shipping the remaining 8,518 tons of ore to the smelter, will sell its tugs and discontinue present operations. There is said to be still about 96,000 tons of refractory zinc-copper ore which may be treated later. The net income of the Tonopah Mining Co. for 1919 was $402,206.89.

Divide—There are no new developments known in the Divide district. Favorable indications, and some ore, are reported in the Gold Zone, Belcher Extension, and Pay Divide. No information is available concerning developments in the Tonopah Divide mine. Regular shipments are being made to the MacNamara mill. A total of 6,365 ft. of sinking is said to have been done in 19 shafts last year.

To date operations in the Divide district have been disappointing, but it is a little premature to call the district a failure. It seems difficult to believe that the Tonopah Divide should have encountered, accidentally, the only existing large commercial orebody in the entire district. It is quite possible that present development work, in the shape of crosscuts and drifts, may result in other discoveries. It is certain that if the Tonopah-Divide orebody, which dips steeply, is taken as typical, the chances for finding other ore shoots are better in crosscutting and drifting than in shaft sinking.

Willard—The Jose-Davis company is said to be putting some ore running $80—$100 gold per ton through the Gibson mill, recently installed. Raising from the face of the lower tunnel on the Sheepherder, the Jose-Davis has again cut the high-grade shoot. Ore of milling grade had been struck in this tunnel 100 ft. from the portal.

Tuscarora—Work will be resumed soon by the Holden M. & M. Co., it is announced by David J. Cook, manager. Plans include rebuilding the mill, recently burned.

New York interests will make a final examination of the Rose Silver Gold Co.'s property in May. The tunnel is now in 360 ft. and the vein should be cut within the next 40 ft. It is 3 ft. wide and carries gold and silver ore of good grade.

Hamilton—Thomas Lynch and associates, of Tonopah, have taken over the Ward group on Treasure Hill, in the old camp of Hamilton, about 30 miles west of Ely.

Carson City—The Nevada Public Service Commission has been asked to secure a rate of $2.50 per ton, instead of $3.80 as now being charged, on iron ore from the Brunswick section to coast points. This ore is in demand—some of it has been shipped to Japan—and with the rate asked it is believed that shipments of 500 tons per week will go out. The rate on the longer haul from Barth, Nev., to the Utah smelter is but $2 per ton.

Searchlight—The Duplex mine at Searchlight is shipping 40-50 tons per week, netting $110 per ton. The ore is closely sorted and but few men are employed.

The dumps of the old Rand mine at Searchlight have been purchased by W. O. North, formerly with the United Eastern mine at Oatman. They contain about 6,000 tons of good milling ore. A contract has been let to haul this to the Duncan cyanide mill for treatment.

Goodsprings—Construction of the mill of the Consolidated Spanish Silver Belt is progressing.

NEW MEXICO

Stockholders of Woodward Company Bid in Property at Sale—Empire Zinc Resumes

Lordsburg—A lease has been taken from George S. Utter on the old Minneapolis claim by J. C. Woodward, of Silver City.

The Ruby Silver Mining Co. has purchased the Lucky Strike group of claims which adjoins its property at Gold Hill.

The Last Chance mine, taken over under option about a year ago by B. Prescott and others, has been turned back to the owners. A 50-ton mill which had been installed has recently been sold.

Pinos Altos—A flotation unit has been added to the new mill of the Calumet & New Mexico Mining Co. This was made necessary to handle certain grades of custom ores that are being offered.

Silver City—At a recent sale, Charles Tate, of Amherst, Nova Scotia, representing stockholders of the Woodward Mining Co., bid in the property for $43,560.20. The sale was ordered by the court to satisfy a judgment obtained by the Empire Trust Co. for $40,269 principal and interest on bonds and $2,293.82 representing money paid out by the trustee, together with costs. The property consists of ten silver claims in the Bald Mountain mining district.

Hanover-Fierro—The Empire Zinc company has resumed operations on a large scale.

OKLAHOMA

Joplin-Miami District

Tar River—The Kitty mine, owned by Kansas City interests, resumed operation of its mill March 29, following a five-weeks' shutdown owing to a fire.

At the Anna Beaver mine construction of the surface hopper is well under way and the surface track to the field shaft laid.

At the Standard Mining Co.'s property a new run of ore has been found, located near the center of the lease.

Picher—The Lucky Syndicate Co. is moving the Grayson concentrator from near Joplin and rebuilding it on lease northwest of Picher where the original mill burned down two years ago. A new shaft is being put down. The mill will not be started until this shaft is into ore, which is found at about 220 ft.

The Hunt Co. has almost completed the mill it is erecting to take the place of the one lost by fire. The St. Louis S. & R. Co. put its new mill, two miles east of Picher, in operation on April 1.

George Beck of Miami has sunk a new shaft into lead dirt on a lease northwest of Picher, and plans the construction of a new mill.

UTAH

Tintic Standard Begins Work on Experimental Mill Near Warm Creek—Miners Scarce at Park City

Eureka—Shipments from the Tintic district for the week ended March 27 were 162 cars compared with 149 cars the week before. The Chief Cons. shipped 36 cars, Dragon Consolidated 28, and Tintic Standard 23.

The Sunbeam, the earliest location in the Tintic district, is being worked under lease after an idleness of a number of years, and is producing milling ore chiefly. The shaft and old workings have been cleaned out to the 350-ft. level.

The Tintic Standard has begun work on its experimental mill, which is to be built near Warm Creek east of Goshen. This company, which is the second largest shipper of silver ores in the state, is seeking to utilize its low-grade ores as well as those of higher grade.

Park City—Shipments for the week ended March 27 were 2,206 tons of ore compared with 1,892 tons the week before, as follows: Judge Mining, 657 tons; Silver King Coalition, 552; Daly West, 216; Ontario Silver, 564; Naildriver, 110; Daly, 107. The Park City district is very active, although hampered to some extent by labor shortage.

The Judge Mining & Smelting is making heavy shipments of lead concentrates, as well as keeping its electrolytic zinc plant in steady operation on zinc concentrates.

The Park-Utah company is opening the eastern section of the camp, so far relatively undeveloped.

CANADA

British Columbia

Franklin—It is reported that erection of a concentrator at the Union mines is considered by the owners. More than 7,000 tons of milling ore are on the dump.

Ontario

Porcupine—The main shaft at the McIntyre mine is now down 1,550 ft. The main vein has been crosscut at the 1,250-ft. level, where it showed a width of 14 ft. of good ore. Crosscuts have been started on the 1,375 and 1,500 ft. levels, and as soon as the vein is picked up here, sinking will be continued. The mill is treating 600 tons of $11 ore per day.

Porcupine-Crown, which was reopened a short time ago, is milling over 100 tons per day. A merger has been arranged between it and the Thompson-Krist properties. The deal provides for the sale of the two properties to a new company, having a capital of 3,000,000 shares, at $1 per share. Porcupine Crown is to get 2,000,000, and the Thompson-Krist 1,000,000 shares. The new company will be under the direction of the present Porcupine-Crown management. The Porcupine-Crown turns over the property, plant, mill and stores, and $20,000 in cash, while the Thompson-Krist turns over all its property and $10,000 cash. Before the Vipond property was closed down, several hundred feet of drifting was done from its 400-ft. level into Thompson-Krist ground, and two small shoots of good ore were developed.

Kirkland Lake—During February the Lake Shores mines milled 1,435 tons of ore, and recovered $40,126, or an average of $28 per ton, which is a record for the company. This tonnage is somewhat below normal, but is shortly expected to show an increase.

Plans have been made for starting work on the new 150-ton mill for the Wright-Hargraves property.

Cobalt—Temiskaming is treating 100 tons of ore per day, and is working 17 machines, compared with two a year ago. Reports have been circulated regarding important new discoveries, but it is understood that these are small in extent.

Chronology of Mining, March, 1920

March 1—Franklin K. Lane, Secretary of the Interior, retired from office—Homestake Mining Co., Lead, S. D., put new wage scale into effect—U. S. Supreme Court decided U. S. Steel Corporation and subsidiaries do not form "a combination in restraint of trade," in violation of Sherman Anti-Trust Law—Trojan Mining Co., in South Dakota, voluntarily increased the wages of all employees—All mining companies in Coeur d'Alene district, Idaho, increased employees' wages by 50c. per day, bringing them by so much above war-time maximum.—Canadian regulations relating to petroleum and natural gas became effective as amended.

March 3—Magnesite tariff bill favorably reported to Senate by Finance Committee.

March 4—Van Dyke Copper Co., Miami, Ariz., broke world's record in shaft sinking, by sinking 308 ft. in 31 days, or 9.93 ft. per day.—Koenig Hall, chemistry building of Michigan College of Mines, destroyed by fire.—Joseph A. Williams, employee of American Smelting & Refining Co., seized by Mexican bandits; he was released March 10.

March 7—Carbon dioxide from fire which broke out last year in Argonaut mine, at Jackson, Cal., caused closing of shaft of Kennedy mine adjoining.—Golconda mine, upper Henson Creek, Col., lost assay office and boarding house by snowslide.

March 8.—U. S. Supreme Court ruled that stock dividends are not taxable under Sixteenth Amendment or otherwise.

March 9—Ontario Mining Association organized at Toronto—Patrick Foley, employee of Magnolia Petroleum Co., Tampico, Mexico, killed by Mexican bandits.

March 8-10—Annual meeting of the Canadian Mining Institute at Toronto.

March 10—Senate adopted Gore resolution asking President for information regarding restrictions imposed by other countries on United States citizens engaged in exploring and developing oil lands in other countries, particularly in Mexico.

March 11—Fire in El Bordo mine, Pachuca, Hidalgo, Mexico, trapped 136 men in shaft.

March 12—President of Mexico issued decree authorizing ten-year concessions for developing oil lands on Mexican national territory, under certain restrictions.

March 15—U. S. Supreme Court dissolved injunction which had tied up placer claim developments at Copper Canyon, Nev., for seven years—Colorado Metal Mining Association began conference to develop plan for stimulating production of low-grade ores—John Barton Payne took oath of office as Secretary of the Interior.

March 18-20.—American Association of Petroleum Geologists held fifth annual meeting at Dallas, Tex.

March 20—Final report of second Industrial Conference called by President Wilson made public, advocating "employee representation."

March 21—Senate Finance Committee acted favorably on House tariff bills regarding zinc and tungsten.

March 22—Representative L. T. McFadden introduced bill to encourage gold mining by levying excise tax of 50c. per pennyweight on sales of gold and of articles containing gold for other than monetary purposes—Gold producers met at Tonopah, Nev., and laid plans for organizing Nevada Chapter of American Mining Congress.

MEN YOU SHOULD KNOW ABOUT

W. T. Lundy is visiting mines in the Slate Range district of California.

E. S. Boalich has returned to San Francisco from a professional trip to southern Nevada.

B. F. Tibby, of Salt Lake City, is making an extensive field examination of oil lands near Bakersfield, Cal.

Lafayette Hanchet has been elected president of the Utah Power & Light Co., to succeed **D. C. Jackling**, recently retired.

R. P. McLaughlin, California State Oil and Gas Supervisor, has been in Texas and will visit Washington, D. C., early in April.

Charles S. Haley, who has been in Peru and Bolivia on professional business for the past several months, will return to New York about May 1.

John T. Reid, mining engineer, Lovelock, Nev., will leave New York City for Nevada early in April, and will not return to New York until next Fall.

Louis S. Cates, assistant general manager of the Utah Copper Co., has returned to Salt Lake City, Utah, after an absence of about three weeks in the East.

Stanley G. Sears, representing the War-Minerals Relief Commission, has completed a survey of properties on the Cuyuna Range claiming relief under the commission rulings.

C. T. Brown, general manager for New Mexico properties of the Empire Zinc Co., Denver, Col., has been visiting the Hanover and Fierro, N. M., properties of that company.

H. S. Wollan, resident engineer for the Lake Superior division of the Great Northern Railroad, has been appointed assistant general superintendent of the same division, with offices in Duluth, Minn.

A. C. Hansen, assistant chief engineer for the Mesabi Range operations of the Republic Iron & Steel Co., has been made superintendent of the Cambria mine of the same company at Negaunee, Mich.

Lester H. Woolsey, recently resigned from the Department of State, as noted in these columns on March 27, will form a partnership with ex-Secretary Robert Lansing for the practice of international law.

Russell McDowell, superintendent of the Grant mine of the Interstate Iron Co., has been made superintendent of the company's new washing plant at the Hill-Annex mine, at Calumet, Minn. Mr. McDowell will have charge of construction and later of operation.

N. O. Lawton, consulting engineer for the Blast Furnace Products Corp., and general superintendent for the Vermont Copper Co., South Stratford, Vt., is now in New York City. For the present he may be addressed at the office of the latter company, 50 East 42d St.

Gus Scogland succeeds John Seward as manager in Salvador of the various properties of El Salvador Silver Mines Co., Divisadero, El Salvador, C. A. Mr. Scogland has been manager, for the past five years, of the Butters Salvador Mine, Ltd., at San Sebastian.

George E. Farish, managing director of El Salvador Silver Mines Co., Inc., left the Salvador properties March 16 on a business trip to San Francisco and other Western points. Mr. Farish expects also to be in New York City during May, and will return to El Salvador early in June of this year.

F. W. Freeman, of Denver, Col., is the intermontane representative of the American Mining Congress, at the meeting called by Director Van. H. Manning, U. S. Bureau of Mines, to discuss the proposed regulations of well drilling, producing and gaging of oil and gas under the new Federal Leasing Law. Judge Freeman is now in Washington conferring with the committee.

A. Livingstone Oke, mining engineer, has resumed professional practice and is now consulting engineer and manager for some mines on the Isthmus of Panama being opened up by an English capitalist. Major Oke, who has just completed five years' service in the Royal Garrison Artillery, will be remembered by many as a contributor to the *Engineering and Mining Journal*. His address is: Ancon, Canal Zone.

SOCIETY MEETINGS ANNOUNCED

An International Mining Convention is to be held at Nelson, B. C., during the week June 7-12.

The New York Section of the American Electrochemical Society has postponed its March meeting to a date in May to be announced later.

The American Chemical Society will hold its fifty-ninth meeting at St. Louis, Mo., April 12 to 16 inclusive. At the general meeting on April 13 E. P. Costigan will speak on "The Chemical Industry and Legislation." On Wednesday or Thursday—before the Division of Industrial Chemists, C. W. Balke will present "Effect of Impurities on the Metallurgy of Tungsten," and V. Lenher "Selenium and Tellurium."

The Society for the Promotion of Engineering Education holds its 27th annual meeting June 29 to July 2, 1920, at the University of Michigan. The general topic for this meeting will be "Co-operation," and the program is being arranged by President Greene. The discussion of relations between technical engineering societies and the S. P. E. E. will be opened by President Ira N. Hollis of Worcester Polytechnic and first president of Engineering Council. Professor Hollis will speak on "Co-operation with the National Engineering Societies." The new Alumni Hall will be the social center.

Engineering Section of the National Safety Council has called a conference of all interested in engineering and accident prevention, to be held at Engineering Societies Building, 29 W. 39th St., New York City, on April 27 next. This conference is designed to assist in bringing into closer touch the engineering world and the safety movement. The morning session will consider the relationship between safety and engineering efficiency, and the subject of safety education in technical schools. The afternoon session will be devoted to safety standards, the movement for uniformity therein, and the council's part in that movement. Sidney J. Williams, secretary and chief engineer, may be addressed at the headquarters of the section, 168 North Michigan Ave., Chicago, Ill.

American Institute of Chemical Engineers will hold its summer meeting in Canada, during the week of June 21-26. Business sessions, reading of papers, and one or two local excursions will be features of the meeting at Montreal on the 21st and 22nd. A visit to the British-American Nickel Corporation, Ltd., the refinery at Ottawa, to the government buildings, and to the Bureau of Mines laboratories, will be made on Wednesday, the 23d, and Thursday and Friday will be devoted to the power development and the electrolytic industries at Shawinigan Falls. June 26, Saturday, will be spent at La Tuque, where the Brown Co.'s sulphite pulp mill, using the explosion process, will be inspected. From here a pleasure excursion through lakes and streams has been planned. The program of papers and the excursions are being arranged by J. C. Olsen, secretary, Polytechnic Institute, Brooklyn, N. Y.

The Rocky Mountain Coal Mining Institute, the **American Mining Congress**, and the **Colorado Metal Mining Association** are arranging midsummer sessions in connection with the National First-Aid and Mine Rescue Contest which will be held in Denver, Aug. 20 and 21. The First-Aid meet will be held under the auspices of the U. S. Bureau of Mines. The various organizations will hold separate meetings to consider their own particular problems, and joint meetings will be held to discuss matters of mutual interest.

Though it is unlikely that there will be as many entries for the First-Aid and Mine Rescue Contest as participated in the Pittsburgh meet last year, on account of the other mine interests involved, the meeting will be one of great national importance, and will be largely attended by mining men from all over the country. The arrangements for the national contests are in the hands of D. J. Parker, U. S. Bureau of Mines Station, Pittsburgh, Pa. Decisions will be according to Bureau standards, and suitable trophies will be awarded.

THE MARKET REPORT

Published in part in San Francisco and mailed from there to our Western subscribers as a special service pending the arrival of the *Engineering and Mining Journal*

Silver and Sterling Exchange

April	Sterling Exchange	Silver		April	Sterling Exchange	Silver	
		New York, Cents	London, Pence			New York, Cents	London, Pence
1	390½	126½	72⅛	5	398½	126½	...
2	393	126	...	6	403¼	127	72
3	397	126	...	7	397⅝	126	72⅛

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

Daily Prices of Metals in New York

April	Copper	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
1	18.75@18.85	61¾@62¼	63 @63½	8.80@8.90	8.60@8.65	8.40@8.45
2	18.75@18.90	61¾@62¼	63 @63½	8.90@9.00	8.65@8.75	8.40@8.45
3	18.80@18.90	61¾@62¼	63 @63½	9.00	8.75	8.40@8.45
5	18.80@18.90	61¾@62¼	63 @63½	9.00	8.75	8.40@8.45
6	18.80@18.90	62 @62¼	62¾@63¼	9.00@9.25	8.75@9.00	8.40@8.45
7	18.80@18.90	62 @62¼	61½@62	9.00@9.25	8.75@9.00	8.35@8.40

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for the deliveries constituting the major markets, reduced to basis of New York, cash, except where St. Louis is the normal basing point. All prices are in cents per pound.

Copper is commonly sold on terms "delivered," which means that the seller pays the freight from refinery to buyer's destination. The delivery cost varies, and it would be confusing to figure net prices on individual transactions. Consequently, an average deduction is made from the "delivered" price. At present the average cost of delivery from New York refineries is 0.15c. per lb., and that deduction is made to arrive at the New York price. When copper is sold f. o. b. or f. a. s. New York, of course no deduction is made.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other special shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. We quote New York price at 35c. per 100 lb. above St. Louis. Tin is quoted on the basis of spot American tin, 99 per cent grade, and spot Straits tin.

London

April	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic						
	Spot	3 M		Spot	3 M	Spot	3 M	Spot	3 M
1	108	111¼	116	351¾	351¾	42¾	44¾	49	52¼
2	....	....	...	....	....	...	...	...	...
3	....	....	...	....	....	...	...	...	...
5	....	....	...	....	....	...	...	...	...
6	105½	108⅝	114	350	349½	40	42¼	48½	51¼
7	105	108	113	341¼	341¼	40¼	42¼	47	49¾

The above table gives the closing quotations on the London Metal Exchange. All prices are in pounds sterling per ton of 2,240 lb.

Metal Markets

New York, April 7, 1920

The volume of metal sales for the week ending today has been below normal, chiefly on account of the Easter holidays. No business was done in London on Friday, Saturday, and Monday. Copper continues strong and active and slightly higher. Sales in recent months have surpassed the production. Lead is scarce and higher, selling in New York at 9c. and upward. Zinc has sagged slightly. Sterling exchange and marks are higher; francs unchanged. The premium on gold has naturally declined in London, although it is still very substantial.

Copper

The market for copper is strong and slightly rising, although there has been little business the last few days, due to the Easter holidays abroad. Owing to the same causes, there was little export business. In London copper quotations were slightly down, which is partly attributable to the greater value of the pound sterling. The prices obtained for actual large sales were fairly uniform at around 19c. delivered, or 18.80@18.85c. net refinery, which we quote, although small lots on the outside market were sold as high as 19¼c., delivered. Total sales of 320,000,000 lb. have been reported for March, including 62,000,000 foreign. Total sales from December to March inclusive, have been over a billion pounds, or more than the production. This has tended to diminish the stocks, and producers are optimistic. Should the extension of credits to foreign buyers by the Copper Export Association crystallize as planned, foreign sales will of course increase tremendously.

Lead

The lead market has stiffened since our last report, and today the A. S. & R. official price of 9¼c. for New York delivery, which has remained unchanged for some time, has been obtained for some lots, although it is likely that most of the business has been done under this figure. But little prompt metal is to be had. Consumers of lead continue to do a large business, and a steady market around 9c. is generally expected.

Zinc

A declining London market had some effect on the domestic business, and a sagging tendency was in evidence today, compared to the fairly strong tone at the end of last week. At the present rate of exchange, zinc is selling in London on a basis of 8c. St. Louis, indicating but little demand for the metal from European consumers. American sellers have been compelled to accept business within a half cent of this figure in order to get it at all. Most of the local trade is for domestic consumption and for May and June delivery. For prompt delivery, a slight premium may be asked in some cases. The galvanizing business is reported slack.

High-grade zinc is in good demand and scarce, selling up to 9½c. New York. Even the foreign inquiry is fairly good. Brass special is in demand at 10 to 15 points premium.

Tin

The market for tin has been extremely quiet during the last week, and but little change in price took place up to today, when there was a considerable decline in the London price of Straits, for both spot and future, which was reflected in the local market. Consumers are apparently not interested, and most of the selling abroad seems to be forced.

Electrolytic tin was quoted as follows: April 1, 62⅞@63c.; April 2, 63@63⅛c.; April 3, 63@63⅛c.; April 5, 63⅛@63⅛c.; April 6, 63⅛@63⅛c.; April 7, 62⅞c.

Straits tin for future delivery was quoted as follows: April 1, 62⅛@62⅜c.; April 2, 62⅛@63c.; April 3, 62⅛@63c.; April 5, 62⅜@63c.; April 6, 62⅛@63c.; April 7, 61¼@61⅜c.

Gold and Silver

Gold was quoted in London on April 1 at 105s. No quotation on April 2, 3, and 5, on account of the Easter holidays. On April 6 the price was 103s.; on April 7, 103s. 2d. The decline in the price of gold naturally keeps pace with the value of the pound sterling.

Foreign Exchange — Sterling was quoted yesterday at above $3.98, an increase over $3.86, the figure a week previous. A shipment of gold by the British Treasury to New York, to apply to the maturity of the Anglo-French loan, is one of the factors which is regarded by some bankers as largely psychological, whereas others point to the greatly increased exports of Great Britain, which are nearly to pre-war figures, as showing the strength of Britain's financial position. Marks have increased to 1.52c., as compared with 1.39c. a week ago. In units to the dollar, francs were quoted at 14.87, showing no change from a week ago. Italian lire showed a slight decline to 20.92, as compared with 20.62 a week ago. Canadian discounts again rose to 9 per cent.

Silver—The market during the last week covers the Easter holiday period. Business was practically suspended for most of the time. Quotations from China show some recession, and the edge is taken off activity for that market. Some buying is going on, but transactions are rather limited.

Mexican dollars at New York: April 1, 96¾; April 2, 96; April 3, 96; April 5, 96½; April 6, 97¼; April 7, 96.

Other Metals

Aluminum—Ingot is quoted at 31½ @33c., with sales at 32c.; No. 12, 31½c.; sheets, 18 gage and heavier, 44.2c. Open market quotations are: 98-99 per cent virgin metal, 31@32c.; 98-99 per cent remelt, 30½@31½c.; No. 12 remelt, 29@30c.; powdered aluminum, 60@65c. Market firm at current prices.

Antimony—Chinese and Japanese for prompt or March delivery, 10¾@10⅞c. per lb. Quiet but firm. Domestic market firmer, with ordinary brands quoted at spot 10½c.; futures at 11¼@ 11½c. W. C. C. brand, 11c. duty paid; Cookson's, 16½c.

[1]**Needle Antimony** — The market for Chinese needle antimony in lump form is firm at 8¾c. per lb., with a rather quiet demand. Standard powdered needle antimony (200 mesh) is quoted at from 11@12c. per lb., according to quantity.

Bismuth—Unchanged at $2.70 per lb. for 500-lb. lots.

Cadmium—No change. Quoted at $1.40@$1.50 per lb.

[1]**Cerium Metal** — There has been no change from the price of $8@$9 per lb. in ingot form.

Cobalt—Metallic, per lb., unchanged, $2.50@$3.

Iridium is nominally quoted at $300; unchanged; metal is very scarce.

Magnesium—Metallic, 99 per cent or over pure, $1.60@$1.85 per lb. Unchanged.

[1]**Molybdenum Metal** in rod or wire form, 99.9 per cent pure, is still selling at $32@$40 per lb., according to gage.

Nickel—Ingot, 43c.; shot, 43c.; electrolytic, 45c. Prices are established over long periods without change.

Palladium Metal—Quoted at $115@ $125 per troy oz., 99 per cent pure. No activity.

Platinum—Weaker, not much doing, $130@$133. Demand slight.

Quicksilver—Firmer with good demand. Quoted at $103@$105 per 75-lb. flask. Stocks are getting low. San Francisco telegraphs $90@$100, steady.

[1]**Selenium**, Black, powdered, amorphous, 99.5 per cent pure, continues to be quoted at $1.75@$2 per lb., depending on quantity.

[1]**Thallium Metal**—Selling at $18@$20 per lb., ingot, 99 per cent pure, depending on quantity.

Metallic Ores

Chrome Ore—Market firm. Freight situation still bad. Quoted 60@85c. per unit for material containing 35-40 per cent Cr_2O_3 and 70c.@$1.25 per unit for ore running 48 per cent Cr_2O_3 and over.

Iron Ores—Lake Superior ores, per ton delivered at Lower Lake ports, remain at prices fixed last year, as follows: Old Range bessemer, $7.45; Old Range non-bessemer, $6.70; Mesabi bessemer, $7.20; Mesabi non-bessemer, $6.55. Vesselmen are still withholding boats for higher ore rates than the $1 per ton contract rate.

[1]**Manganese Ore**—Quoted at 75@85c. per unit ore containing 45 per cent Mn and over. Market firm. Chemical ore (MnO_2) quoted at $80@$90 per gross ton.

[1]**Molybdenite**—Quoted at 75@85c. per lb. of contained sulphide for 85 per cent MoS_2.

[1]**Tantalum Ore**, guaranteed minimum 60 per cent tantalic acid, is still selling at 65@70c. per lb. in ton lots.

Titanium Ores—Ilmenite, 2c. per lb. of 52 per cent TiO_2. Unchanged. Rutile, standard imported Norwegian grade, carrying a minimum of 95 per cent titanium dioxide, in the form of concentrates, is quoted at 11c. per lb.

Tungsten Ore—Business has been done in Chinese ore from $6.75@$7, and market shows improvement. Scheelite held firm at $7@$10 per ton.

Uranium Ore (Carnotite)—$2.75@$3 per lb. for 96 per cent of the contained oxide (U_3O_8). Ores must contain a minimum of 2 per cent U_3O_8.

Vanadium Ore—$6 per lb for 99 per cent of the vanadic oxide (V_2O_5) contained.

Zinc and Lead Ore Markets

Joplin, Mo., April 3—Zinc blende, per ton, high, $54; basis 60 per cent zinc, premium, $51; Prime Western, $50; fines and slimes, $47.50@$45; calamine, basis 40 per cent zinc, $35. Average settling prices: Blende, $51.93; calamine, $38.38; all zinc ores, $51.78.

Lead, high, $109.45; basis 80 per cent lead, $107.50; average settling prices, all grades of lead, $105.89 per ton.

Shipments for the week: Blende, 16,222; calamine, 260; lead, 2,278 tons. Value, all ores the week, $1,094,670.

About 10,000 tons of zinc ore was sold this week, against less than 5,000 tons last week. Sellers would not accept last week's cut price. This week the price was set up to the $50 basis, with the result of a double tonnage sold.

This is the third week of large shipments, with plenty of cars, and the large bins of ore are fading away.

Platteville, Wis., April 3—Blende, basis 60 per cent zinc, $55 base for premium and Prime Western grades. Lead ore, basis 80 per cent lead, $105 per ton. Shipments for the week: Blende, 1,704; calamine, 60; lead, 32 tons. Year: Blende, 21,021; calamine, 1,020; lead, 1,856; sulphur ore, 209 tons. During the week 1,751 tons blende was shipped to separating plants.

Non-Metallic Minerals

Asbestos—Quoted per short ton f.o.b. Thetford, Broughton and Black Lake mines, Quebec, Canada. Freight rate from mines to Sherbrooke, Quebec, over Quebec Central R.R., 20c. per cwt; from Sherbrooke to New York, 27½c., carload lots. Crude No. 1, $1,750@ $2,000; crude No. 2, $1,100@$1,500; spinning fibres, $500@$750; magnesia and compressed sheet fibres, $250@ $400; single stock, $95@$150; paper stock, $60@$75; cement stock, $25@ $30; floats, $14@$16 per short ton.

Magnesite—Dead burned, for refractory (see Refractories).

Calcined Magnesite — High-grade caustic calcined, in lump form, is selling at $35@$40 per ton in carload lots f.o.b. California points. The price of freshly ground calcined, suitable for the flooring trade, is $60@$65 per ton f.o.b. Eastern points.

Barytes—Pressure of heavy demand and difficulty in transportation have practically paralyzed this item. White floated is listed at $35@$40 and off-color at $25@$30 per ton.

Blanc Fixe (Barium Sulphate)—Dry, 4½@5½c. per lb.; pulp, $30@$50 per ton f.o.b. New York.

Chalk—English, extra light, 5@7c. per lb.; light, 4½@6c. per lb.; dense, 4@5c. per lb. f.o.b. New York. Unchanged.

Graphite — Present quotations for crucible flake are: 85 per cent carbon content, 7½c. per lb.; 86 per cent, 8c.; 87 per cent, 8½c.; 88 per cent, 9c.; 89 per cent, 9½c.; 90 per cent, 10c.; 91 per cent, 10½c.; 92 per cent, 11c.; over 92 per cent, 12½c. per lb. delivered. Mexican amorphous graphite is being sold at $55@$60 per short ton; Korean, 3¾c. per lb., Madagascar, 9c.; Ceylon, 4¾@ 16c., according to quality.

Gypsum—Wholesale price, plaster of paris in carload lots, is $3.25 per 250-lb. bbl. Sufficient demand, but scarcity of material.

Nitrate—Spot quoted at $3.85 per cwt., ex vessel, Atlantic ports. Futures $3.85, no market.

[1] Furnished by Foote Mineral Co., Philadelphia, Pa.

Pyrites—Spanish pyrites quoted at 16c. per unit for furnace-size ore, free from fines, c.i.f. Atlantic ports. Domestic pyrite, fine, 16c. per unit. Situation unchanged.

Sulphur—Prices average $18 per ton for domestic, and $20 for export, f.o.b. Texas and Louisiana mines. Car situation slightly improved.

China Clay (Kaolin)—Imported lump, $25@$35 per ton; imported powdered, $30@$60 per ton; domestic lump, $10@$20 per ton; domestic powdered, $25@$40 per ton f.o.b. New York. Unchanged.

Feldspar—Unchanged, supplies are very tight and producers are way behind their contracts. $13.50@$18 still holds.

Fluorspar — Gravel, f.o.b. mines, is quoted at $25 net ton. Nominal prices: Acid grade, lump, $30@$45; acid grade, ground, $52@$57, f.o.b. mines. One dealer reports he has all the orders he can handle.

Fuller's Earth—Remains firm at $25@$30 for domestic and $35@$40 for foreign, with little material available at these prices.

Monazite—Product carrying a minimum of 6 per cent thorium oxide, $42 per unit is quoted, duty paid.

Phosphate Rock—Prices quoted per long ton at port are: 68 per cent tricalcium phosphate, $6.85; 70 per cent, $7.35; 74 to 75 per cent, $10; 75 per cent minimum, $10.50; 77 per cent mimimum, $12.50. Practically no domestic business, owing to lack of cars. At mines, 74 per cent is quoted at $9.15 per long ton. Market firm with distribution behind demand, owing to car shortage. Present demand is principally for prompt deliveries.

Pumice Stone—Imported, 3@6c. per lb.; domestic, 2½c. per lb. Unchanged.

Strontium Ore, guaranteed 90 per cent pure, is selling at $15@$18 per ton, carload lots, with lower prices on large contracts.

Talc—Domestic, $20@$60 per ton; imported, $60@$70 per ton f.o.b. New York.

Zircon—Washed, iron free, continues to be quoted at 10c. per lb. Zirkite—In carload lots, $90@$100 per ton is quoted. Pure white oxide, 99 per cent, is quoted at $1.15 per lb. in ton lots.

Ferro Alloys

Ferrocarbontitanium—For 15-18 per cent material, $200@$250 f.o.b. Niagara Falls, N. Y. Unchanged.

[1]Ferrocerium—Conditions abroad continue to cause a reduction in price of the American goods, and this alloy is now selling at $12@$15 per lb.

Ferrochrome—6-8 per cent carbon, 20@21c. per lb. of chromium contained; 2-4 per cent carbon, 21@22c. per lb. of chromium contained.

Ferromanganese — English, prompt, $200; last-half delivery, $175@$200; domestic, prompt, $235@$250; and last half, $200@$225. Firmer than last week.

Spiegeleisen—In the same position as was previously reported, the average sale ranging from $60 to $70 per ton.

Ferromolybdenum—Standard grades, carrying from 50 to 60 per cent molybdenum metal, with low sulphur, phosphorus, and arsenic, are quoted at $2.25@$2.75 per lb. of contained metal.

Ferrosilicon—$85@$90, 50 per cent delivered, spot and contract. Electrolytic, delivered Pittsburgh Valleys, Cleveland: 50 per cent, $80; 75 per cent, $140. Bessemer, f.o.b. Jackson, Ohio, 10 per cent, $59.50; 11 per cent, $62.80; 12 per cent, $66.10.

Ferrotungsten — 70-80 per cent W, 90c.@$1.10 per lb. W contained.

Ferro-uranium—35-50 per cent U, $7 per lb. of U contained. Unchanged.

Ferrovanadium—30-40 per cent, $6.50@$7.50 per lb. of V contained.

Metal Products

Copper Sheets—No change since Jan. 1 price of 29½c. per lb.; wire, quoted 22½c. base; price firmer.

Zinc Sheets—$12.50 per 100 lb., less 8 per cent on carload lots, f.o.b. smelter; zinc plates, 12c. per lb. Unchanged.

Lead Sheets—Full lead sheets, 12½c.; cut lead sheets, 12½c. Unchanged.

Nickel Silver—18 per cent, 39½c. lb. Unchanged.

Yellow Metal — Dimension sheets, 26¾c.; sheathing, 25¾c.; rods, ⅜ to 3 in., 23¾c. Unchanged.

Refractories

Chrome Brick—Unchanged at $70@$75 per net ton, f.o.b. Chester, Pa.

Chrome Cements—Unchanged at $45@$50 per net ton, f.o.b. Chester, Pa.

Clay Brick—First-quality fire clay, $45@$50 per 1,000, f.o.b. Clearfield, Pa.; second quality, $40@$45 per 1,000, f.o.b. Clearfield, Pa.

Magnesite—Dead burned, $50@$55 per net ton, f.o.b. Chester, Pa.; brick, 9 x 4½ x 2½ in., $80@$85 per net ton, f.o.b. Chester, Pa. Unchanged

Silica Brick—$50@$55 per 1,000, f.o.b. Mt. Union, Pa.

Iron Trade Review

Pittsburgh, April 6, 1920

In some quarters the opinion is held that steel production has now nearly attained the limit, but the more common view is that it can be increased materially when transportation conditions are restored to normal. The fact that upon the removal of Government price restrictions Connellsville furnace coke jumped from $6, the Government price, to $11 or $12, and has since held that range, seems to be sufficient evidence that transportation conditions are still far from satisfactory. Coal likewise jumped to high prices, $4.50 to $5 having obtained in the last few days on small prompt lots.

[1]Furnished by Foote Mineral Co., Philadelphia, Pa.

Almost the whole of New England is embargoed in one way or another, and it is extremely difficult to get steel shipments through. Steel has been moving West fairly well. Car shortage is still much in evidence, but reports this morning are of large receipts, particularly of gondolas. Box cars are extremely scarce. The American Sheet & Tin Plate Co., which must ship in box cars exclusively, except that recently some tin plate customers have instructed it to ship in stock cars, reduced its accumulation during March from 60,000 to 57,000 tons, the tonnage representing about ten days' production.

The question in the steel market now is how long it will be until premiums disappear and the market settles to the Steel Corporation or Industrial Board price schedule, for, to the surprise of most of the independents, and the annoyance of some, it has become practically certain that eventually the Steel Corporation prices will prevail. Meanwhile, buyers will purchase from independents only in hand-to-mouth manner.

Pig Iron—The market continues extremely quiet, but prices have become firm, being no doubt stiffened by the sharp rise in coke following the removal of Government restrictions. W. P. Snyder & Co. report their computation of average prices obtained on all reported sales of Valley iron in lots of 1,000 tons or over in March at $42 for bessemer and $41.50 for basic. The quotational average on foundry was $42, all prices being Valley, and the market is now quotable at these figures.

Steel—Unfinished steel remains scarce. An odd lot of about 500 tons of sheet bars, as noted above, was sold at $75 for shipment next week, the steel becoming available on account of an embargo preventing an expected shipment for export. We quote billets at $65 to $70, small billets at $75 to $80, sheet bars at $70 to $75 and rods at $65 to $75, the market being decidedly inactive all around.

Charcoal and Coke

Charcoal—Large quantities sell as follows. Willow, 7c per lb.; hardwood, 4½c. per lb., in 250 lb. bbl.

Connellsville—Upon the removal of Government price limits on Connellsville coke, $6 on furnace and $7 on foundry, a few sales of prompt and April furnace coke, together with one contract for the remaining nine months of the year, were put through at $9, and then the market started advancing, ruling in the last two or three business days at $11 to $12 for furnace and $13 to $15 for foundry, per net ton at ovens. Production has increased only slightly. Furnaces had expected a price of about $9, but when the market went above that they refused to buy beyond April. Considerable business was done, as a number of contracts and informal arrangements ended with March.

METAL STATISTICS

Monthly Average Prices of Metals

Silver

	New York			London		
	1918	1919	1920	1918	1919	1920
January	88.702	101.125	132.827	44.356	48.438	79.846
February	85.716	101.125	131.295	42.792	48.027	85.005
March	88.082	101.125	125.551	43.620	48.171	74.194
April	95.346	101.125	.....	47.215	48.886	.....
May	99.505	107.135	.....	48.980	52.104	.....
June	99.500	110.430	.....	48.875	53.896	.....
July	99.625	106.394	.....	48.813	54.133	.....
August	100.292	111.370	.....	49.077	58.835	.....
September	101.125	114.540	.....	49.500	61.668	.....
October	101.125	119.192	.....	49.500	64.049	.....
November	101.125	127.924	.....	48.969	70.065	.....
December	101.125	131.976	.....	48.492	76.432	.....
Year	96.772	111.122	.....	47.516	57.059	.....

New York quotations cents per ounce troy, 999‰ fine. London, pence per ounce, sterling silver, 925 fine.

Copper

	New York		London			
	Electrolytic		Standard		(b) Electrolytic	
	1919	1920	1919	1920	1919	1920
January	(a)	18.918	92.238	118.095	106.619	123.238
February	16.763	18.569	78.700	120.188	95.700	126.950
March	14.856	18.331	76.821	109.533	82.071	118.348
April	15.246	.....	77.300	.....	82.200	.....
May	15.864	.....	77.767	.....	81.227	.....
June	17.610	.....	83.062	.....	85.900	.....
July	21.604	.....	99.576	.....	103.046	.....
August	22.319	.....	97.300	.....	106.429	.....
September	21.755	.....	100.767	.....	.....	.....
October	21.534	.....	103.418	.....	.....	.....
November	19.758	.....	98.894	.....	.....	.....
December	18.295	.....	103.708	.....	.....	.....
Year	18.691	.....	90.796	.....	.....	.....

(a) No market. (b) See note on page 490.

Lead

	New York		St. Louis		London	
	1919	1920	1919	1920	1919	1920
January	5.432	8.561	5.316	8.300	37.227	47.095
February	5.057	8.814	4.784	8.601	28.675	50.256
March	5.226	9.145	4.992	8.894	27.952	46.054
April	4.982	.....	4.722	.....	24.888	.....
May	5.018	.....	4.773	.....	23.852	.....
June	5.340	.....	5.070	.....	22.544	.....
July	5.626	.....	5.408	.....	23.457	.....
August	5.798	.....	5.583	.....	25.330	.....
September	6.108	.....	5.853	.....	28.473	.....
October	6.487	.....	6.249	.....	34.731	.....
November	6.808	.....	6.649	.....	41.202	.....
December	7.231	.....	6.955	.....	.....	.....
Year	5.759	.....	5.530	.....	28.590	.....

Tin

	New York				London	
	1919		1920			
	99%	Straits	99%	Straits	1919	1920
January	67.702	.....	61.596	.....	248.557	376.512
February	66.801	.....	58.466	59.932	223.963	395.750
March	67.934	.....	61.037	61.926	236.843	369.489
April	72.500	.....	.....	.....	225.275	.....
May	72.500	.....	.....	.....	234.398	.....
June	71.240	.....	.....	.....	238.263	.....
July	68.000	.....	.....	.....	253.272	.....
August	57.226	.....	.....	.....	273.625	.....
September	54.482	.....	.....	.....	280.102	.....
October	54.377	.....	.....	.....	279.239	.....
November	53.307	.....	.....	.....	283.556	.....
December	53.870	.....	.....	.....	314.113	.....
Av. year	63.328	.....	.....	.....	257.601	.....

Zinc

	New York		St. Louis		London	
	1919	1920	1919	1920	1919	1920
January	7.272	9.483	6.922	9.133	56.045	58.643
February	6.623	9.058	6.273	8.708	46.150	61.338
March	6.500	8.881	6.150	8.531	38.500	53.467
April	6.465	.....	6.114	.....	36.118	.....
May	6.429	.....	6.079	.....	35.477	.....
June	6.901	.....	6.551	.....	36.763	.....
July	7.873	.....	7.523	.....	41.815	.....
August	7.789	.....	7.160	.....	39.338	.....
September	7.510	.....	7.473	.....	40.955	.....
October	7.823	.....	7.827	.....	43.630	.....
November	8.177	.....	8.350	.....	46.588	.....
December	8.700	.....	8.350	.....	53.101	.....
Year	7.338	.....	6.988	.....	42.879	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Pig Iron, Pittsburgh

	Bessemer ‡		Basic ‡		No. 2 Foundry	
	1919	1920	1919	1920	1919	1920
January	$33.60	$40.47	$31.40	$39.88	$32.40	$39.86
February	33.60	42.954	31.40	42.61	32.40	43.40
March	32.54	43.40	31.40	42.90	29.12	43.40
April	29.35	.....	27.15	.....	28.15	.....
May	29.35	.....	27.15	.....	28.15	.....
June	29.35	.....	27.15	.....	28.15	.....
July	29.35	.....	27.15	.....	28.15	.....
August	29.35	.....	27.15	.....	28.15	.....
September	29.35	.....	27.15	.....	28.15	.....
October	29.35	.....	27.15	.....	28.30	.....
November	31.60	.....	31.56	.....	32.16	.....
December	36.57	.....	35.32	.....	36.86	.....
Year	$31.11	.....	$29.26	.....	$28.35	.....

‡ As reported by W. P. Snyder & Co.

Monthly Copper Production

The table which appears herewith represents the crude-copper content of blister copper, in pounds.

MONTHLY CRUDE COPPER PRODUCTION, 1919-1920

	November	December	January	February
Alaska shipments	6,067,735	6,032,677	7,909,682	5,121,609
Arizona:				
Arizona Copper	2,900,000	2,900,000	3,000,000	3,000,000
Calumet & Arizona	6,320,000	5,778,000	5,034,000	5,268,000
Cons. Ariz. Smelting	670,000	615,000	690,000	910,000
Inspiration	7,000,000	7,200,000	7,200,000	7,200,000
Magma	579,000	719,800	707,585	729,546
Miami	3,718,965	4,519,910	4,461,247	4,089,520
New Cornelia	2,896,000	2,640,000	2,456,000	2,872,000
Old Dominion	2,261,400	2,534,000	2,504,900	2,103,000
Phelps Dodge	6,453,000	5,061,000	5,622,000	5,535,500
Ray	3,832,000	3,860,000	316,970	340,384
Shattuck Arizona	238,969	260,284	3,899,073	3,885,000
United Verde	5,100,000	5,450,000	6,550,000	6,490,000
United Verde Extension	2,288,414	3,740,024	3,676,312	2,977,898
Michigan:				
Calumet & Hecla	9,498,756	8,931,567	9,690,671	8,660,052
Other Lake Superior	6,420,000	6,420,000	6,420,000	6,420,000
Montana:				
Anaconda	14,120,000	3,300,000	18,100,000	18,500,000
East Butte	1,902,580	1,844,540	1,738,840	1,460,360
Nevada:				
Nevada Cons	3,525,000	4,500,000	4,181,938	3,850,000
New Mexico:				
Chino	3,749,434	3,388,524	3,081,937	3,176,489
Utah:				
Utah Copper	9,482,451	9,005,591	8,693,589	9,211,806
Eastern Smelters	1,500,000	1,500,000	1,610,000	1,600,000
Total reported	100,284,735	89,740,633	107,544,744	103,401,164
Others, estimated	17,005,000	13,257,000	14,240,000	14,240,000
Total United States	117,289,735	102,997,633	121,784,744	117,641,164
Imports: Ore and concentrates, etc	14,049,903	7,135,731	9,926,390	.....
Imports in blister, etc	21,079,182	21,453,007	5,065,683	.....
Grand total	152,418,820	131,586,371	136,776,817	.....
British Columbia:				
Granby Cons	1,776,863	1,544,446	1,975,439	2,180,000
Mexico:				
Boleo	1,146,880	933,097	1,054,550	911,051
Cananea	3,900,000	3,600,000	3,000,000	3,400,000
Phelps Dodge Mexican properties	2,331,000	2,397,000	2,340,000	2,050,000
Other foreign:				
Cerro de Pasco	4,752,000	4,644,000	4,616,000	4,718,000
Chile	10,000,000	6,016,000	7,508,000	.....
Katanga	5,511,500	473,989	4,519,430	4,133,625
Backus & Johnston	1,712,000	1,882,000	716,000	926,000

Production of the United States by months since the beginning of the year and the corresponding figures for 1918 and 1919 were as follows:

	1918	1919	1920
January	165,431,568	135,733,511	121,784,744
February	160,011,364	111,649,512	117,641,164
March	185,525,168	102,040,460	.....
April	163,207,096	98,808,998	.....
May	181,070,350	92,652,975	.....
June	166,723,599	95,856,570	.....
July	159,329,031	100,369,247	.....
August	165,550,799	107,994,040	.....
September	157,992,487	108,703,075	.....
October	168,638,775	115,143,143	.....
November	159,217,588	117,289,735	.....
December	161,801,916	102,997,633	.....

COMPANY REPORTS

Calumet & Arizona Mining Co.

Copper; Arizona

The Calumet & Arizona Mining Co. reports for the year ended Dec. 31, 1919, that the company's production of refined copper, silver, and gold was as follows: From domestic ores treated, 43,788,078 lb. copper, 955,478 oz. silver, and 26,986 oz. gold; in domestic ores sold, 1,203,029 lb. copper, 39,888 oz. silver, and 1,544 oz. gold; from foreign ores, 2,749,615 lb. copper, 367,887 oz. silver, and 7,314 oz. gold; from other sources, 2,495,291 lb. copper. Total, 50,236,013 lb. copper, 1,363,254 oz. silver, and 35,844 oz. gold. Sales of copper during the year amounted to 47,190,043 lb., of which there was delivered 29,725,176 lb. Precious metals per ton of refined copper from the company's ores amounted to $76.25. During the year dividends to the amount of $1,927,563 were paid. Total ore mined amounted to 565,963 wet tons, or 552,078 dry tons. The company shipped to outside smelters 54,429 tons of high-sulphur ores, low in copper. During the year a total of 701,450 dry tons of ore was treated in the smelter, compared with 850,894 dry tons during 1918. This included 189,460 dry tons of custom ores.

On account of the curtailment in operation by the New Cornelia Copper Co., which consumes practically the entire acid plant production, the plant was operated at about 66.5 per cent capacity throughout the year, being entirely closed down from April 24, 1919, to July 13, 1919. The plant produced 48,595 tons of 60 deg. acid, as compared with 67,110 tons in 1918.

Barnes-King Development Co.

Gold; Marysville, Montana

Report of operations of the Barnes-King Development Co. for the year 1919 states that the North Moccasin mine produced during the year 25,843 tons, having an average value of $6.56 per ton. The Kendall property was leased under similar terms as for the preceding three years, and work was confined to the ground above the 100-ft. level. The Shannon property produced 36,740 tons of ore, containing $415,887 in gold value and $10,222 in silver value. Since 1911, and to the close of 1919, there were submitted to the company 411 properties, of which 237 were examined, and on 12 of them, including the North Moccasin, Piegan-Gloster and Shannon, additional development work was done. Search for good new properties will be energetically continued. During 1919 the company paid four dividends, two of 10c. each and two of 5c. each per share, totaling $120,000, and making $420,000 in dividends paid to date.

Federal Mining & Smelting Co.

Silver-Lead-Zinc; Wallace, Idaho

Report for year ending Dec. 31, 1919: Ore reserves are 2,887,880 tons. During the year 320,655 tons was mined. Operating expenses were $1,417,346; ore sales were $1,767,153. Dividends amounting to $449,478 were paid. Cash in hand amounts to $268,667. The company is investigating new properties.

Hecla Mining Co.

Silver-Lead; Wallace, Idaho

Annual report for year ending Dec. 31, 1919: Ore reserves are 1,549,833 tons. Dividends for the year were $600,000. A total of 208,906 tons of ore was treated. Operating expense was $4.467 per ton; operating profit, $3.636; total, $759,632. Silver totaling 795,058 oz. and 24,726,015 lb. of lead were produced.

Daly West Mining Co.

Silver-Lead; Utah

The Daly West company, for the year ending Jan. 1, 1920, reports receipts of $194,557, against expenditures of $216,205; showing a reduction of surplus of $21,647. Metal contents of all ores sold were: silver, 187,098 oz.; lead, 1,060,000 lb.; copper, 130,010 lb.; gold, 163 oz. The crude ore averaged 38.7 oz. silver, 9.78 per cent lead, 1.45 per cent copper, and 0.03 oz. gold, and sold for $34.97.

Since Jan. 1 new ore has been found, and values have increased. A quarterly dividend of 15c. a share has been declared, payable April 1. This is the first in seven years.

Consolidated Interstate-Callahan Mining Co.

Zinc, Lead, Silver; Coeur d'Alene District, Idaho

Report for the year ending Dec. 31, 1919: Mining operations covered only four and one-half months during the last part of the year. Ore to the value of $487,303 was sold; total operating expense was $499,508, and total expenditures of all kinds, $602,902. Total accumulated surplus is $618,630. No dividends were paid; 67,952 tons of ore was mined, having an average assay of 17.17 per cent zinc, 7.73 per cent lead and 2.57 oz. silver.

Shattuck-Arizona Copper Co.

Copper; Arizona

For the year ended Dec. 31, 1919, this company showed gross income of $1,069,698; expenses, $1,991,591; depreciation and depletion, $164,606; net loss, $186,499. Nevertheless, stockholders were paid $262,500 dividends out of previously accumulated surplus.

March Mining Dividends

The following is a partial list of mining dividends paid in March:

MARCH MINING DIVIDENDS

U. S. Mining and Metallurgical Companies	Situation	Per Share	Totals
Ahmeek Mining Co., c	Mich.	$0.50	$100,000
Am. Smelt. & Refining, common	U. S.-Mex.	1.00	609,980
Am. Smelt. & Refining, pfd	U. S.-Mex.	1.75	875,000
Argonaut Consol., g	Cal.	.05	10,000
Arizona Silver Mines	Nev.	.03	13,500
Caledonia Mining, l. s	Idaho	.01	26,050
Calumet & Arizona Mining, c	Ariz.	1.00	642,520
Chino Copper	N. Mex.	.375	326,242
Consol. Interstate-Callahan, z	Idaho	.50	161,651
Copper Range, c	Mich.	.50	197,500
Cresson Consol. Gold	Col.	.10	122,000
Davis-Daly Copper, c., s	Mont.	.25	150,000
Federal Mining & Smelting, pfd	Idaho	.75	90,000
Golden Cycle, g	Col.	.03	45,000
Hecla Mining, l. s	Idaho	.15	150,000
Kennecott Copper Corp	.....	.50	1,393,530
Nevada Consolidated Copper	Nev.	.25	499,864
Osceola Consolidated, c	Mich.	.50	48,075
Quincy Mining, c	Mich.	1.00	110,000
Ray Consolidated Copper	Ariz.	.25	394,294
St. Joseph Lead	Mo.	.50	704,734
Tintic Standard, l. c	Utah	.10	117,470
United Verde Copper	Ariz.	1.50	450,000
Utah Copper	Utah	1.50	2,436,735
Yellow Pine, z., l., s	Nev.	.03	30,000
South American Companies			
Cerro de Pasco Copper	Peru	1.00	898,229

The month has been marked by many reductions in amount and some passed dividends, notably that by the Calumet & Hecla Mining Co., whose stock fell to its lowest point since 1897 (334) when the passed dividend was announced. On the other hand, Consolidated Interstate-Callahan announced a dividend for 1920 after having passed its 1919 dividends.

The dividend by the Quincy Mining Co., wrongly included in the February table, is correctly included in the above table for March. The report that Mayflower-Old Colony Copper Co. had declared a dividend was incorrect.

MINING STOCKS

Week Ended April 3, 1920

Stock	Exch.	High	Low	Last	Last Div.
COPPER					
Adventure	Boston	....	....	*75	
Ahmeek	Boston	....	....	65	Mar. '20, $ .50
Alaska-B.C	N. Y. Curb	1⅛	1	1 1/16	
Algomah	Boston	....	....	*40	
Allouez	Boston	....	....	34	Mar. '19, 1.00
Anaconda	N. Y.	64⅝	63	63¾	Feb. '20, 1.00
Ariz. Com'l	Boston	13¼	12⅛	12⅛	Oct. '18, .50
Big Ledge	N. Y. Curb	7/16	3/16	7/16	
Bingham Mines	Boston	7	6⅛	6⅞	Sept. '19, .25
Boston & Ely	Boston Curb	....	....	*55	
Butte & Bal	Boston	....	....	*30	
Butte & Lond	Boston Curb	....	....	†*10	
Calaveras	Boston Curb	....	....	1	
Calumet & Ariz	Boston	66¼	65	65	Mar. '20, 1.00
Calumet & Hecla	Boston	360	355	355	Dec. '19, 5.00
Calumet & Jerome	N. Y. Curb	....	....	1/16	
Can. Copper	N. Y. Curb	1⅛	1⅛	1⅛	
Centennial	Boston	14	12½	14	Dec. '18, 1.00
Cerro de Pasco	N. Y.	56⅛	53½	54	Mar. '20, 1.00
Con. Ariz	N. Y. Curb	....	....	⅛	Dec. '18, .05
Con. Copper M	N. Y. Curb	5	4½	4⅝	
Chile Cop	N. Y.	19	18⅛	18⅛	
Chino	N. Y.	37½	36	36	Mar. '20, .37½
Cop. Range	Boston	45⅛	44	44	Mar. '20, .50
Crystal	Boston Curb	....	....	†*30	
Crystal Cop (old)	Boston Curb	....	....	†*4	
Davis-Daly	Boston	12	11⅛	11⅛	Mar. '20, .25
East Butte	Boston	15⅜	15¼	15¼	Dec. '19, .50
First Nat'l	Boston Curb	....	....	†1⅛	Feb. '19, .15
Franklin	Boston	4	4	4	
Gadsden Copper	N. Y. Curb	1	1	1	
Granby Consol	N. Y.	49⅛	47	47	May '19, 1.25
Greene-Can	N. Y.	36	36	36	Feb. '19, 1.50
Hancock	Boston	6	6	6	
Helvetia	Boston	3½	3½	3½	
Houghton	Boston Curb	....	....	†*75	
Howe Sound	N. Y. Curb	4⅛	4	4	Jan. '20, .05
Indiana	Boston	....	....	*75	
Inspiration Con	N. Y.	60¼	59⅜	59½	Jan. '20, 1.50
Iron Cap	Boston Curb	....	....	†11	Feb. '19, .25
Isle Royale	Boston	35⅛	34	34	Sept. '19, .50
Jerome Verde	N. Y. Curb	....	....	1/16	
Kennecott	N. Y.	32⅜	31⅛	31⅞	Mar. '20, .50
Keweenaw	Boston	....	....	1⅛	
Lake Copper	Boston	4½	4½	4½	
La Salle	Boston	....	....	2⅜	
Magma Chief	N. Y. Curb	5/16	1/4	5/16	
Magma Copper	N. Y. Curb	38	38	38	Jan. '19, .50
Majestic	Boston Curb	....	....	†*15	
Mason Valley	N. Y. Curb	....	....	2⅛	
Mass Con	Boston	5¼	5¼	5¼	Nov. '17, 1.00
Mayflower-O. C.	Boston	9¼	8⅝	8⅝	Feb. '20, 1.00
Miami	N. Y.	24	23¼	23⅜	Feb. '20, .50
Michigan	Boston	6½	6½	6½	
Mohawk	Boston	71⅛	69	70	Feb. '20, 1.50
Mother Lode(New)	N. Y. Curb	5⅛	5	5⅛	
Nev. Con	N. Y.	15⅛	14⅞	14⅞	Mar. '20, .25
Nixon Nev	N. Y. Curb	23	20	23	
Nev. Douglas	Boston Curb	....	....	†*15	
New Arcadian	Boston	4⅛	3⅞	4⅛	
New Baltic	Boston Curb	....	....	†4	
New Cornelia	Boston	21⅜	21	21	Nov. '18, .25
North Butte	Boston	17⅛	16⅜	16⅞	Oct. '18, .25
North Lake	Boston	....	....	*50	
Ohio Copper	N. Y. Curb	....	....	1/16	
Oneco	Boston Curb	....	....	†*60	
Ojibway	Boston	....	....	2	
Old Dominion	Boston	36	33½	33½	Dec. '18, 1.00
Osceola	Boston	50	48½	48½	Mar. '20, .50
Quincy	Boston	58	58	58	Mar. '20, 1.00
Ray Con	N. Y.	20	19⅛	19⅜	Mar. '20, .25
Ray Hercules	N. Y. Curb	....	....	1	
St. Mary's M. L	Boston	50½	50	50	Dec. '19, 2.00
Seneca	Boston	16¼	15½	15½	
Shannon	Boston	1⅛	1⅛	1⅛	Nov. '17, .25
Shattuck-Ariz	N. Y.	....	....	12	Jan. '20, .25
South Lake	Boston	....	....	*30	
South Utah	Boston	*20	*20	*20	
Superior	Boston	6	4½	5½	Apr. '17, 1.00
Superior & Boston	Boston	5	4¼	4¼	
Tenn. C. & C	N. Y.	13⅜	11⅛	13	May '18, 1.00
Trinity	Boston	1⅛	1⅛	1⅛	
Tuolumne	Boston	....	....	*85	
United Verd. Ex	Boston Curb	....	....	†*35	Feb. '20, .50
Utah Copper	N. Y.	78¼	77¼	77¾	Mar. '20, 1.50
Utah Con	Boston	8¼	8¼	8¼	Sept. '18, .25
Utah M. & T	Boston	2½	2¼	2⅜	Dec. '17, .30
Victoria	Boston	....	....	2¼	
Winona	Boston	1¼	1¼	1¼	
Wolverine	Boston	18½	18	18	Jan. '20, .50
LEAD					
Hecla	N. Y. Curb	4½	4½	4⅝	Mar. '20, .15
St. Joseph Lead	N. Y.	16½	16½	16⅝	Mar. '20, .50
Stewart	Boston Curb	....	....	†*16	Dec. '15, .05
Utah Apex	Boston	2⅛	2⅛	2⅛	Nov. '18, .25

*Cents per share. †Bid or asked Mar. 31.

Stock	Exch.	High	Low	Last	Last Div.
ZINC					
Am. Z. L. & S	N. Y.	19⅜	19	19⅛	May '17, 1.00
Am. Z. L. & S. pf	N. Y.	54⅛	54⅛	54⅛	Feb. '20, 1.50
Butte C. & Z	N. Y.	10⅜	9⅞	9⅞	July, '18, .50
Butte & N. Y	N. Y. Curb	⅜	⅜	⅜	
Butte & Superior	N. Y.	28⅛	27⅞	27⅞	Sept. '17, 1.25
Con. Interst. Cal	N. Y.	19	17⅞	18¼	Mar. '20, .50
Natl. Z. & L	Boston Curb	....	....	†*6	May '17, .02
Success	N. Y. Curb	*7	*6	*6½	July '16, .03
GOLD					
Alaska Gold	N. Y.	2⅛	2	2⅛	
Alaska Juneau	N. Y.	3	2⅞	2⅞	
Booth	N. Y. Curb	6	6	6	
Carson Hill	N. Y. Curb	31½	30½	31	
Cresson Gold	N. Y. Curb	....	....	2¾	Mar. '20, .10
Dome Ex	Toronto	....	....	†*26½	
Dome Lake	Toronto	....	....	†*8½	
Dome Mines	N. Y.	12¼	11¾	12¼	Jan. '20, .25
Goldfield Con	N. Y. Curb	*13	*12	*13	Dec. '19, .05
Hedley	Boston	....	....	4½	June '19, .10
Hollinger	Toronto	....	....	†6.50	Feb. '20, .05
Homestake	N. Y.	60	58	60	Sept. '19, .50
Kewanas	N. Y. Curb	*4	*2½	*3	
Kirkland Lake	Toronto	....	....	†*66	
McIntyre Porcupine	Toronto	....	....	†2.15	Jan. '20, .05
Silver Pick	N. Y. Curb	*20	*18	*19½	
Teck-Hughes	Toronto	....	....	†*15	
United Eastern	N. Y. Curb	4	3½	3½	Jan. '20, .21
West Dome	Toronto	....	....	†*9½	
White Caps	N. Y. Curb	16	14	15½	
Yukon Gold	Boston Curb	....	....	†1⅛	June '18, .02½
SILVER					
Adanac	Toronto	....	....	†*5	
Bailey	Toronto	†*6	....	....	Apr. '16, .05
Beaver Con	Toronto	....	....	†*61½	
Conigas	Toronto	....	....	†3.10	Nov. '19, .12½
Crown Reserve	Toronto	†*38	....	....	Jan. '17, .05
Hargraves	Toronto	....	....	†*3	
Kerr Lake	Boston	4⅛	4⅛	4⅛	Sept. '19, 1.00
La Rose	N. Y. Curb	....	....	⅜	Apr. '18, .02
McKinley-Dar	Toronto	†*70	....	....	Jan. '20, .03
Nipissing	N. Y. Curb	11	10⅛	10⅜	Jan. '20, .50
Ontario Silver	N. Y.	9⅛	8⅝	9⅛	Jan. '19, .50
Ophir Silver	N. Y. Curb	⅜	⅜	⅜	
Peterson Lake	Toronto	....	....	†*19½	Jan. '17, .01½
Sil. King Ariz	N. Y. Curb	*50	*40	*42	
Temiskaming	Toronto	....	....	†*45	Jan. '20, .04
Trethewey	Toronto	....	....	†*43	Jan. '19, .05
GOLD AND SILVER					
Atlanta	N. Y. Curb	*3	*2½	*2½	
Batopilas	Boston	....	....	1⅛	
Bost. & Mont	N. Y. Curb	*68	*65	*66	
Cashboy	N. Y. Curb	*11	*9	*10	
El Salvador	N. Y. Curb	3⅞	2⅜	3⅜	
Goldfield Merger	N. Y. Curb	*3	*2	*3	
Jim Butler	N. Y. Curb	*24	*22	*23	Aug. '18, .07
Jumbo Extension	N. Y. Curb	*11	*9	*10	June '16, .05
Louisiana Con	N. Y. Curb	⅜	⅜	⅜	
McNamara Cr	N. Y. Curb	*⅜	*⅜	*3/16	
Nev. Packard	Boston Curb	*25	....	....	Apr. '19, .02
Rochester Mines	N. Y. Curb	....	....	*18	Oct. '18, .02
Tonopah-Belmont	N. Y. Curb	2⅛	2	2⅛	Jan. '20, .05
Tonopah-Divide	N. Y. Curb	2⅛	2 1/16	2⅛	
Tonopah Ex	N. Y. Curb	2⅛	2 1/16	2⅛	Jan. '20, .05
Tonopah Mining	N. Y. Curb	2 1/16	1⅞	2	Oct. '19, .15
West End Con	N. Y. Curb	2	1⅞	1⅞	Dec. '19, .05
SILVER-LEAD					
Caledonia	N. Y. Curb	*35	*34	†35	Jan. '20, .01
Daly-West	Boston	4⅛	4⅛	4⅛	
Fed. M. & S	N. Y.	16⅛	15½	16⅛	Jan. '09, 1.50
Fed. M. & S. pf	N. Y.	40	36	39	Mar. '20, .75
Iron Blossom	N. Y. Curb	1/16	1/16	1/16	Jan. '20, .02½
Marsh Mines	N. Y. Curb	*17	*15	*17	
Rex Con	N. Y. Curb	*9	*8	*9	
Simon S. L	N. Y. Curb	....	....	*1⅛	
Stand. S. L	N. Y. Curb	1/16	1/16	1/16	Oct. '17, .05
Wilbert	N. Y. Curb	9⅛	9	9	Nov. '17, .10
NICKEL-COPPER					
Internat'l Nickel	N. Y.	24⅛	23	23⅛	Mar. '19, .50
Internat'l Nick. pf	N. Y.	....	....	87	Feb. '20, 1.50
QUICKSILVER					
New Idria	Boston	7	6⅛	7	Jan. '19, .25
TUNGSTEN					
Mojave Tungsten	Boston Curb	....	....	†*9	
VANADIUM					
Vanadium Corpn	N. Y.	73⅛	66⅛	71⅛	
GOLD AND PLATINUM					
So. Am. G. & P	N. Y. Curb	....	....	8⅛	
MINING, SMELTING AND REFINING					
A. S. & R	N. Y.	69⅛	68	68⅛	Mar. '20, 1.00
A. S. & R., pf	N. Y.	95⅛	95⅛	95⅛	Mar. '20, 1.75
Am. Sm. pf., A	N. Y.	83	82⅛	82⅛	Jan. '20, 1.50
Natl. Lead	N. Y.	84⅛	82⅛	83⅛	Mar. '20, 1.50
Natl. Lead, pf	N. Y.	....	....	109	Mar. '20, 1.75
U. S. Sm. R. & M.	N. Y.	72⅛	70⅛	70⅛	Jan. '20, 1.50
U. S. Sm. R. & M., pf	N. Y.	47⅛	47⅛	47⅛	Jan. '20, .87½

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IRON AND STEEL METALLURGY

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